INSTALLATION RESTORATION PROGRAM

FINAL

SITE CHARACTERIZATION REPORT
VOLUME I
(Sections 1 through 7)

147TH FIGHTER INTERCEPTOR GROUP
TEXAS AIR NATIONAL GUARD
ELLINGTON FIELD
HOUSTON, TEXAS

MAY 1995

AIR NATIONAL GUARD

HAZWRAP SUPPORT CONTRACTOR OFFICE
Oak Ridge, Tennessee 37831
Operated by MARTIN MARIETTA ENERGY SYSTEM, INC.
For the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-840R21400

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Site Characterization Report, Volume I
A Site Characterization was performed at one site at the 147th Fighter Interceptor Group. The site was the Base Petroleum, Oils, and Lubricants Storage Area. All contamination identified at the site was below the Texas Natural Resource Conservation Commission action limits.

The report recommended that the risk assessment performed as part of the Site Investigation be up-dated with the additional information from this report. If the risk assessment show that no significant risks to human health exist then performed no further action for the site is recommended.

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FINAL

INSTALLATION RESTORATION PROGRAM
SITE CHARACTERIZATION REPORT

147TH FIGHTER INTERCEPTOR GROUP
TEXAS AIR NATIONAL GUARD
ELLINGTON FIELD
HOUSTON, TEXAS

SUBMITTED BY
HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
MARTIN MARIETTA ENERGY SYSTEMS, INC.
OAK RIDGE, TENNESSEE

PREPARED FOR
NATIONAL GUARD BUREAU
WASHINGTON, D.C. 20310
CONTRACT NUMBER 18B-97381C

PREPARED BY
HALLIBURTON NUS CORPORATION
PROJECT NUMBER 1K94

MAY 1995

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TABLE OF CONTENTS
Figures, Tables, Appendices, Aconynms/Abbreviations

Section	Title	Page

TABLES

FIGURES

APPENDICES

ACRONYMS

ANG	Air National Guard
ANGRC	Air Natrional Guard Readiness Center
BLS	Below Land Surface
BNA	Base Neutral/Acid Extractables
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
CRQL	Contract Required Quantitation Limit
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DTIC	Defense Technical Information Center
Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	Environmental Protection Agency
F	Fahrenheit
FID	Flame Ionization Detector
FIG	Fighter Interceptor Group
FSP	Field Sampling Plan
GC	Gas Chromatograph
GC/MS	Gas Chromatograph/Mass Spectrometer
Halliburton NUS	Halliburton NUS Corporation
HAZWRAP	Hazardous Waste Remedial Actions Program
IAG	Interagency Agreement
ID	Inside Diameter
IRP	Installation Restoration Program
JP-4	Jet Petroleum Number 4
LPST	Leaking Product Storage Tank
MCL	Maximum Contaminant Levels
MG/KG	Milligrams Per Kilogram

MG/L	Milligrams Per Liter
MSL	Mean Sea Level
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSC	Media Specific Concentrations
NA	Not Applicable
NASA	National Aeronatics and Space Administration
NCP	National Contingency Plan
NGB	National Guard Bureau
NGS	National Geodetic Survey
NGVD	National Geodetic Vertical Datum
NSF	National Sanitation Foundation
PA	Preliminary Assessment
PID	Photo Ionization Detector
POL	Petroleum, Oils, and Lubricants
PPB	Parts Per Billion
PPM	Parts Per Million
PVC	Poly Vinyl Chloride
QA/QC	Quality Assurance/Quality Control
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SC	Site Characterization
SI	Site Investigation
TCL	Target Compound List
TDS	Total Dissolved Solids
TNRCC	Texas Natural Resource Conservation Commission
TPH	Total Petroleum Hydrocarbons
UG/KG	Micrograms Per Kilogram
UG/L	Micrograms Per Liter
USAF	United States Air Force
USC&GC	United States Coast and Geodetic Survey
USGS	United States Geological Survey
UST	Underground Storage Tank
VOA	Volatile Organic Analysis

EXECUTIVE SUMMARY

The Air National Guard Readiness Center (ANGRC) as part of the Installation Restoration Program (IRP) has conducted a Site Characterization (SC) at the Petroleum, Oils, and Lubricants (POL) Storage Area at Ellington Field Air National Guard Base in Houston, Texas. This document presents the findings of activities undertaken during the SC.

The objective of the SC performed at the Ellington Field Air National Guard Base POL Storage Area was to:

> acquire additional data, as necessary, to define the extent of confirmed environmental contamination by further characterization of the subsurface stratigraphy, aquifer properties and contamination migration pathways.

To accomplish the objective of the SC, the following elements were completed:

- <u>Installation of soil borings and monitoring wells</u> - A total of 22 soil borings were drilled and 5 monitoring wells were installed at the site to characterize geologic and hydrogeologic conditions and for the collection of environmental samples. The horizontal and vertical locations of the soil borings and monitor well locations were determined by means of land survey techniques.

- <u>Collection of environmental samples</u> - A total of 72 (65 samples plus 7 duplicates) subsurface soil and 9 groundwater samples were collected at the site and analyzed at a fixed base laboratory.

- <u>Water level measurements and aquifer testing</u> - Groundwater elevations were determined in order to establish groundwater flow direction and hydraulic gradient across the site. Aquifer test data were used to calculate estimates of aquifer parameters.

- Chemical laboratory analysis - Soil and groundwater samples were sent to a fixed base laboratory for chemical analysis.

- On-Site GC Analysis - Selected soil and groundwater samples were also analyzed on-site using portable field gas chromatography (GC). On-site laboratory results were used as level A screening data only.

- Data evaluation and report preparation - This report was prepared to present the findings of SC activities.

SOIL

Total petroleum hydrocarbon (TPH) concentrations ranged from non-detect to a maximum of 54 mg/kg. Benzene, toluene, ethylbenzene, and xylene (BTEX) were detected in several of the subsurface soil samples. Maximum concentrations detected were 2.5 mg/kg, 3 mg/kg, 8 mg/kg, and 9.9 mg/kg, respectively. 2-butanone was detected at a low concentration in one soil sample. No semi-volatile constituents were detected in any of the soil samples.

Concentrations of TPH and BTEX detected are below Texas Natural Resource Conservation Commission (TNRCC) action limits (i.e., 100 mg/kg TPH and 30 mg/kg total BTEX) for corrective action at petroleum storage tank sites.

GROUNDWATER

Groundwater was encountered at depths ranging from 6.7 to 10 feet below grade. Groundwater flow direction is to the east.

TPH concentrations ranged from non-detect to a maximum of 0.4 mg/l. Benzene, toluene, ethylbenzene, and xylene were not detected in any of the groundwater samples. Acetone, carbon disulfide, and bis(2-ethylhexyl)phthalate were detected at a very low concentration in two of the groundwater samples.

Concentrations of TPH and BTEX are below TNRCC action limits (i.e., 0.5 mg/l TPH, 100 ug/l BTEX) for corrective action at petroleum storage tank sites.

1.0 INTRODUCTION

This report presents findings of activities conducted during the Site Characterization (SC) of the POL Storage Area, Ellington Field Air National Guard Base. Field activities included the characterization of site-specific geological and hydrogeological conditions and the collection of environmental samples for laboratory analysis.

The SC was conducted based upon findings of the Site Investigation (SI) (Halliburton NUS Report R-48-05-016H, January, 1991) which indicated contamination of soils and groundwater at the site. The SI was conducted under CERCLA guidelines.

The objective of the SC was to acquire additional data at the POL Storage Area to support informed decisions regarding remedies that are most appropriate to the site. Meeting the SC objective required further characterization of the subsurface stratigraphy, aquifer properties, and contamination migration pathways. The SC was conducted under State of Texas underground petroleum storage tank guidelines.

The following subsections describe the objectives of the IRP and contain information regarding the general environmental setting of the Base, a brief history of previous investigative activities and remedial actions. The organization of this report is also presented.

1.1 IRP Background and Objectives

In 1975, the Department of Defense (DOD) developed the IRP to identify, report, and correct potential areas of environmental concern resulting from past waste disposal and spill sites on United States Air Force (USAF) installations and to develop remedial actions consistent with the National Contingency Plan (NCP) for those sites which pose a threat to human health or the environment. This is achieved through the Remedial Investigation/Feasibility Study (RI/FS) process in which conclusions and recommendations drawn from validated data are used to structure and guide subsequent activities.

As part of this program, the Air National Guard Readiness Center (ANGRC), through the Air Force Engineering and Services Center, has entered into an

interagency agreement (IAG) with the Department of Energy (DOE) under which DOE will provide technical assistance for the implementation of the ANGRC IRP and related activities. Martin Marietta Energy Systems, Inc. (Energy Systems) has been assigned the responsibility for managing this effort under the IAG. The ANGRC has ultimate responsibility for the Air National Guard (ANG) IRP.

The objective of the ANGRC IRP is to identify the potential environmental problem sites at all ANG installations and to provide timely remediation to protect public health or environment from confirmed and quantified contamination associated with past hazardous waste and spill sites.

ANGRC has requested support from DOE through Energy Systems to determine the extent of contamination at the POL Storage Area, Ellington Field Air National Guard Base. Energy Systems has contracted Halliburton NUS Corporation (Halliburton NUS) to provide technical assistance.

1.2 Installation Description

Ellington Field Air National Guard Base occupies 209 acres of essentially flat coastal plain approximately 15 miles south of downtown Houston in Harris County, Texas. The extent of Ellington Field Air National Guard Base property is shown in Figure 1-1. The area within a 1-mile radius of Ellington Field Air National Guard Base is sparsely populated, however densely populated suburbs of Houston (Pasadena, Friendswood, Clear Lake City, South Houston, etc.) are located within 5 miles of the facility.

Ellington Field is a municipal airport owned and operated by the City of Houston. Ellington Field is used by commercial carriers for passenger and cargo operations. Cargo companies operate warehouse facilities at Ellington Field. NASA uses Ellington Field for flight training and aerospace activities and occupies several buildings at the site. The Texas ANGRC occupies parcels of land within Ellington Field proper as shown on Figure 1-1. This property is located at the northern and southern ends of Ellington Field. Ellington Field is bordered to the west by a golf course and undeveloped land, to the east by open fields and a large commercial sand pit and to the north and south by undeveloped land.

SCALE: 1" = 2000'
REFERENCE: USGS MAP
QUADRANGLE 7.5 MINUTE SERIES
FRIENDSWOOD, TEXAS QUADRANGLE 1982

LEGEND

● – MUNICIPAL WELLS

FIGURE 1-1

DRAWN BY:	D. GROSSHANDLER	SITE LOCATION MAP ELLINGTON FIELD (ANG) HOUSTON, TEXAS	HALLIBURTON NUS Environmental Corporation
DATE:	12/9/93		
GEOLOGIST:	L. BASILIO		
DATE:	12/9/93		
CAD DWG. NO:	FRIEN-1.DWG	SCALE: 1"=2000' / DWG. NO. 1K94-CB0 / REV. 0	

FRIEN-1.DWG/JDT/04-19-94

Ellington Field Air National Guard Base construction began September 14, 1917. The first contingent of air service personnel (the 120th Aero Squadron) arrived November 10, 1917. A variety of military aircraft have used the facility throughout its history, including the T-33, F-4C, C-131, Curtis JN-4 and "Super Guppy" aircraft. Ellington Field Air National Guard Base is now operated by the 147th Fighter Interceptor Group (FIG) of the Texas Air National Guard, which moved onto the property in 1955. The facility also operated as a United States Air Force Base from 1917 through 1976.

1.2.1 Environmental Setting of Ellington Field

1.2.1.1 Meteorology

Net annual precipitation in the vicinity of the base is approximately 48 inches, while net annual lake evaporation is approximately 44 inches. The 1-year 24-hour rainfall intensity is approximately 2.75 inches. The minimum and maximum monthly temperatures of 42° Fahrenheit (F) and 92°F occur in January and July, respectively (U.S. Dept. of Commerce, 1968).

1.2.1.2 Topography and Drainage

The topography of Ellington Field Air National Guard Base is typical of the Gulf Coastal Plain, which is characterized by land sloping gently toward the gulf. The Pleistocene Beaumont Formation, which crops out at the facility, has an average erosional surface slope of 1.65 feet per mile (0.03 percent) from its landward extent to the shoreline. Surface elevations at Ellington Field Air National Guard Base range from 40 feet above mean sea level (MSL) in the northwest corner to 25 feet above MSL in the southeast corner (U.S.G.S., 1982).

The only major surface water body is Horsepen Bayou. This bayou flows eastward approximately 10 miles, where it flows into Armand Bayou, Pasadena Lake, Mud Lake, Clear Lake and, finally, Galveston Bay. Horsepen Bayou and its tributaries receive some overland drainage and runoff from drainage ditches on the Ellington Field Air National Guard Base property. However, due to the relatively flat site topography, a great deal of surface water pools on-site and either evaporates or percolates slowly to the groundwater through semi-permeable surficial clays.

1.2.1.3 Regional Geology

Ellington Field Air National Guard Base is located within the West Gulf Coastal Plain physiographic province. The formations underlying the site are comprised of consolidated and unconsolidated sediments of the Miocene, Pliocene and Pleistocene ages. These formations crop out in belts parallel to the Gulf Coast and dip gently to the southeast. Younger formations crop out nearer the Gulf, older formations further inland. Due to the downdip thickening of the coastal sediments, the older formations dip more steeply than the younger ones (Texas State Board of Water Engineers, 1950).

The sediments comprising these strata were derived largely from the weathering of older Tertiary and Cretaceous formations, and were deposited in fluvial, deltaic, lagoonal and shallow marine environments. Owing to the differing modes of deposition, lithologies are diverse and complexly interbedded, and, therefore, individual beds can rarely be traced over long distances. Layers and lenses of clay grade laterally and vertically into sand zones; sands and gravels likewise grade into clay zones. Characteristic geologic and geomorphic features of the Gulf Coastal Plan include salt domes, growth faults, subsidence faults, scarps, pimple mounds and undrained depressions.

1.2.1.4 Regional Hydrogeology

The geologic formations supplying potable water in the site area are the Pleistocene formations, whose water-bearing units comprise the Chicot Aquifer, and the Pliocene-aged Goliad Sand, whose sand beds comprise the Evangeline Aquifer. The Chicot has a maximum thickness of 700 feet in the site vicinity; the Evangeline a maximum thickness of 2000 feet. Both aquifer systems consist predominantly of complexly interbedded sands and clays (Texas Water Development Board, 1975).

No continuous confining layers overlie the Chicot, and where the Beaumont Formation crops out, the aquifer extends to the ground surface, suggesting that the aquifer is under water table conditions. Although electric logs do not show any definite confining unit above the Evangeline, artesian conditions do exist within the aquifer. This, along with the difference in water level elevations between the two aquifers, suggests that the hydraulic connection between them is minimal.

The Beaumont Formation consists of sediments lying between the base of the Alta Loma sand and fluviatile deposits of Recent Age. The Beaumont was deposited by rivers in forms of deltas and natural levees. Sediments in the upper part are more fine grained than those of the lower part (the Alta Loma sand). Individual sands in the upper part are for the most part extremely lenticular and can be traced for only short distances. The Beaumont Formation outcrops in southeast Harris County. Figure 1-2 is a geological map of the upper gulf coast. Figure 1-3 is geologic cross section of the upper gulf coast.

Available information indicates four municipal wells are located on City of Houston or City of Pasadena property in the vicinity of Ellington Field Air National Guard Base. Figure 1-1 shows the locations of the wells. Well 1, located one block west of Cockran and Brantly Streets was removed in 1989 by the City of Houston. Use of well 2 was discontinued by the City of Houston on July 15, 1990. Wells 3 and 4 are owned by the City of Pasadena and are used by the golf course located west of the Former Base Landfill. These wells produce water from the lower unit of the Chicot aquifer, a massive sand section known as the Alto Loma Sand. Screened intervals in these wells range from 390 to 570 feet below land surface (Texas Water Development Board, 1972). Another well, designated 2P, is located approximately one-half mile upgradient of the POL Storage Area. This well is screened from between 85 and 95 feet below grade.

The base obtains its water from the City of Houston municipal water supply.

1.3 Site Description and History

1.3.1 Site Description

The POL Storage Area is isolated from the main portion of Ellington Field Air National Guard Base, at the south end of the City of Houston property. This site is surrounded by a chain-link fence which approximates the ANGRC property line. The POL Storage Area is bordered by Union Pacific Railroad right-of-way property on the southwest side, Horsepen Bayou on the north side and undeveloped land on the east side. A drainage ditch on the railroad right-of-way flows northwest into Horsepen Bayou, which subsequently flows eastward into Armand Bayou, Pasadena and Mud Lakes, Clear Lake and, finally Galveston Bay.

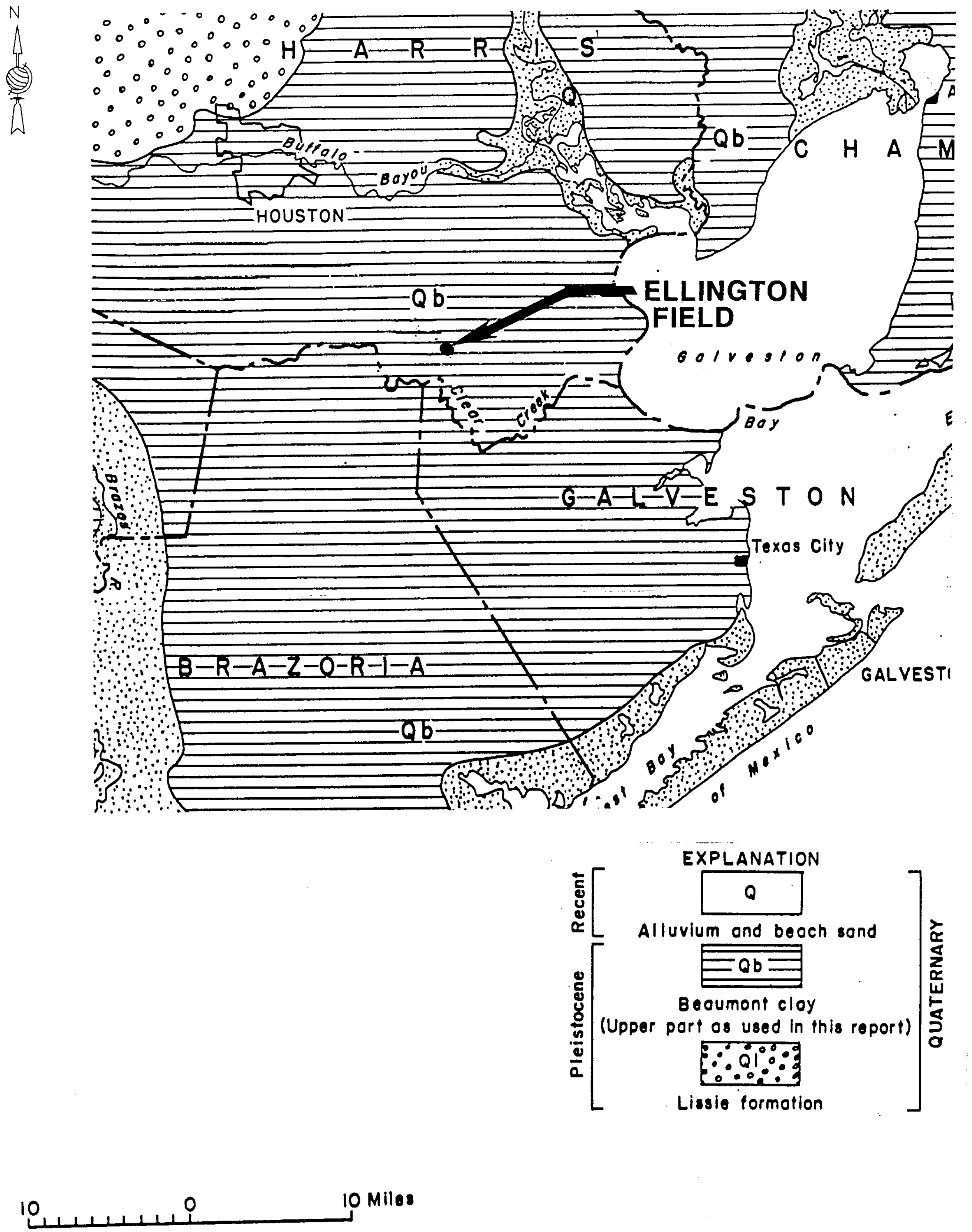

FIGURE 1-2

REFERENCE: USGS MAP, 1937

DRAWN BY:	J. TRAN	GEOLOGIC MAP UPPER GULF COAST	HALLIBURTON NUS Environmental Corporation
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GEOLOGIST:	L. BASILIO		
DATE:	04/19/94		
CAD DWG. NO:	ELLING2.DWG	SCALE: 1"=10' DWG. NO. 1K94– REV. 0	

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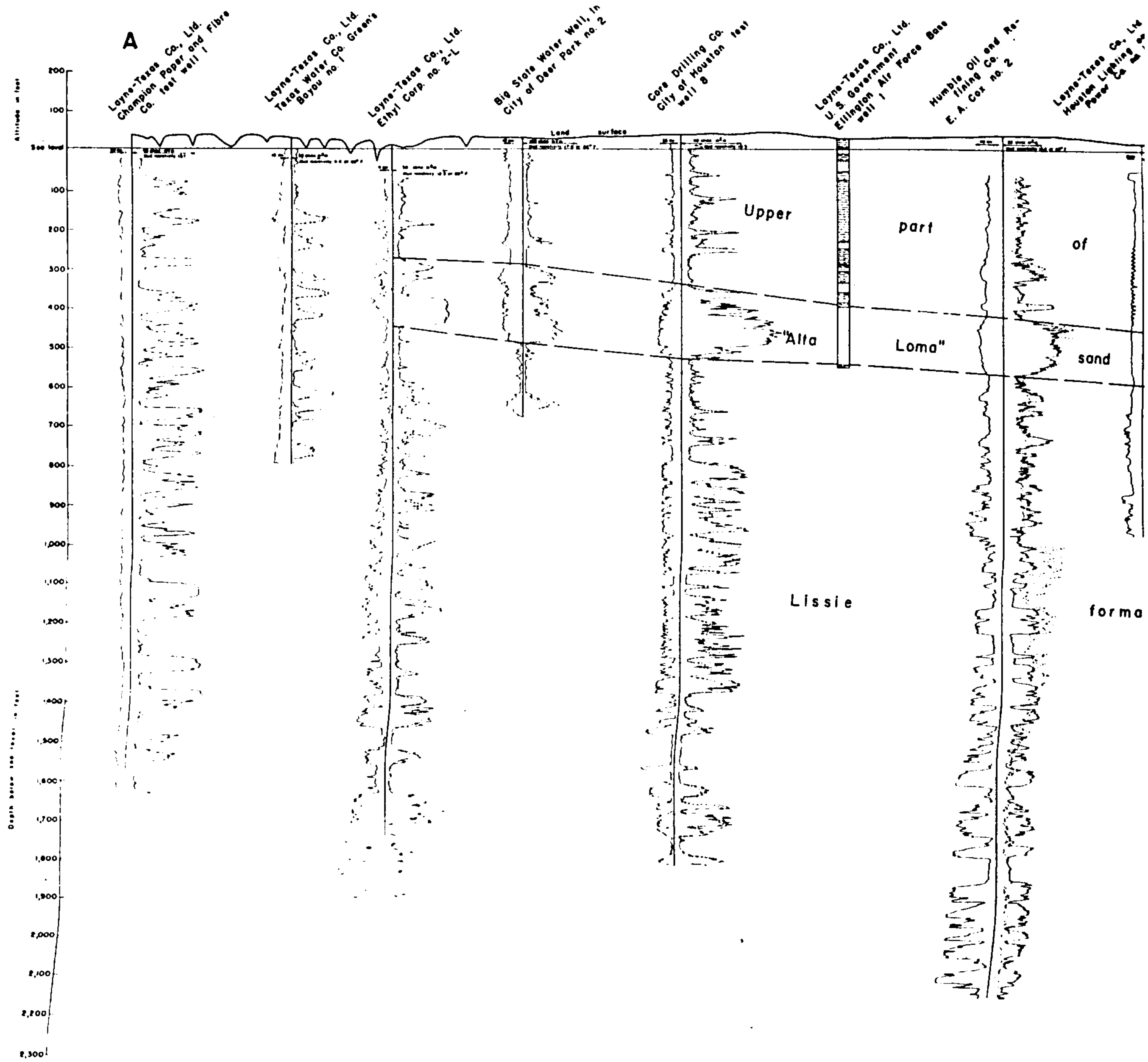
A
Layne-Texas Co., Ltd. Champion Paper and Fibre Co. test well 1
Layne-Texas Co., Ltd. Texas Water Co. Green's Bayou no. 1
Layne-Texas Co., Ltd. Ethyl Corp. no. 2-L
Big State Water Well, in City of Deer Park no. 2
Core Drilling Co. City of Houston test well 8
Layne-Texas Co., Ltd. U. S. Government Ellington Air Force Base well 1
Humble Oil and Refining Co. E. A. Cox no. 2
Layne-Texas Co., Ltd Houston Lighting and Power Co.
Altitude in feet
200
100
Sea level
Land surface
Depth below sea level, in feet
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
1,600
1,700
1,800
1,900
2,000
2,100
2,200
2,300
Upper part of
"Alta Loma" sand
Lissie forma

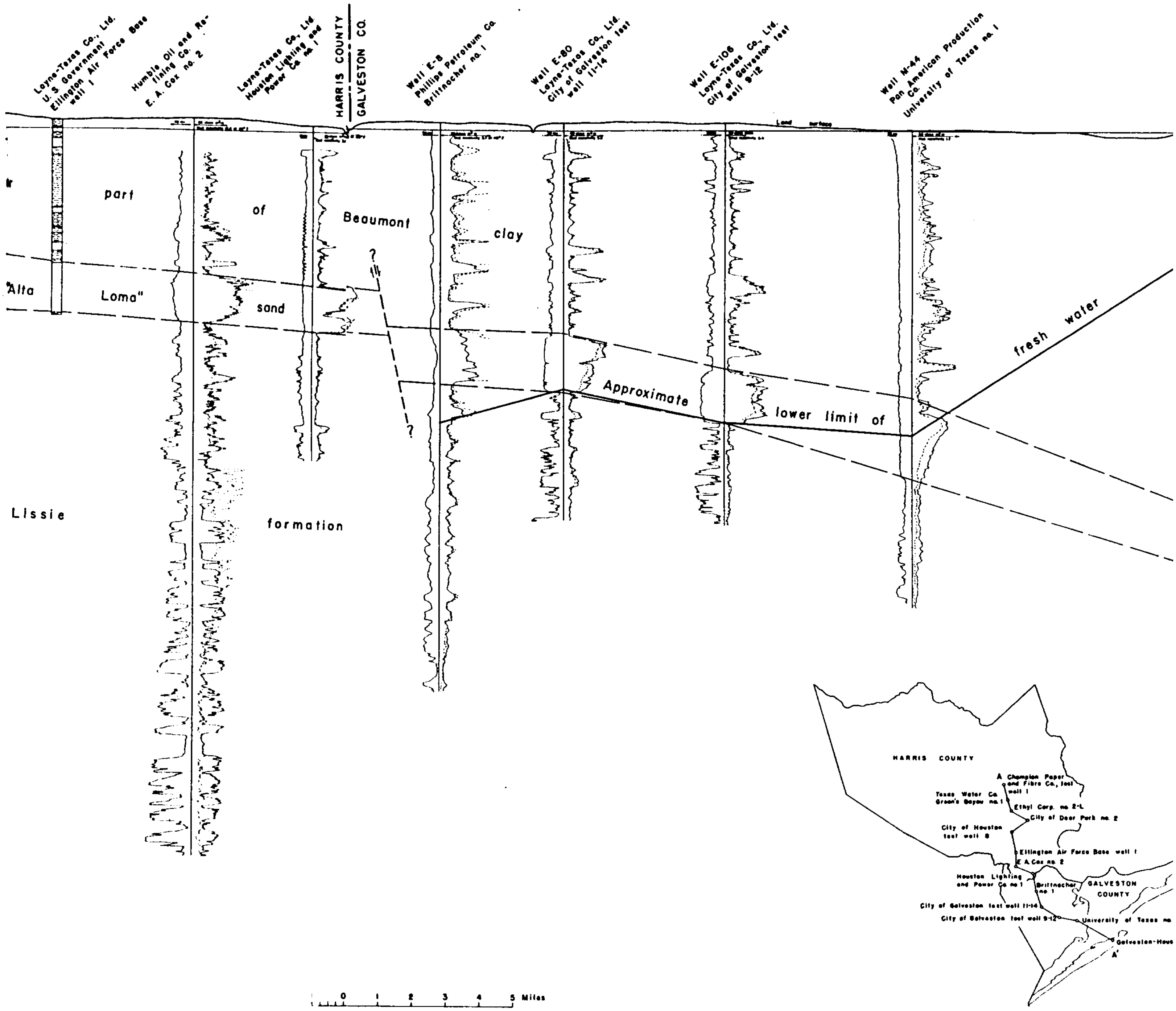

FIGURE 1-3

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GEOLOGIST:	L. BASILO
DATE:	04/19/94
CAD DWG. NO.	ELLING3.DWG

GEOLOGIC CROSS-SECTION
UPPER GULF COAST

SCALE: AS NOTED | BRE. DWG. NO.: 1K94- | REV. 0

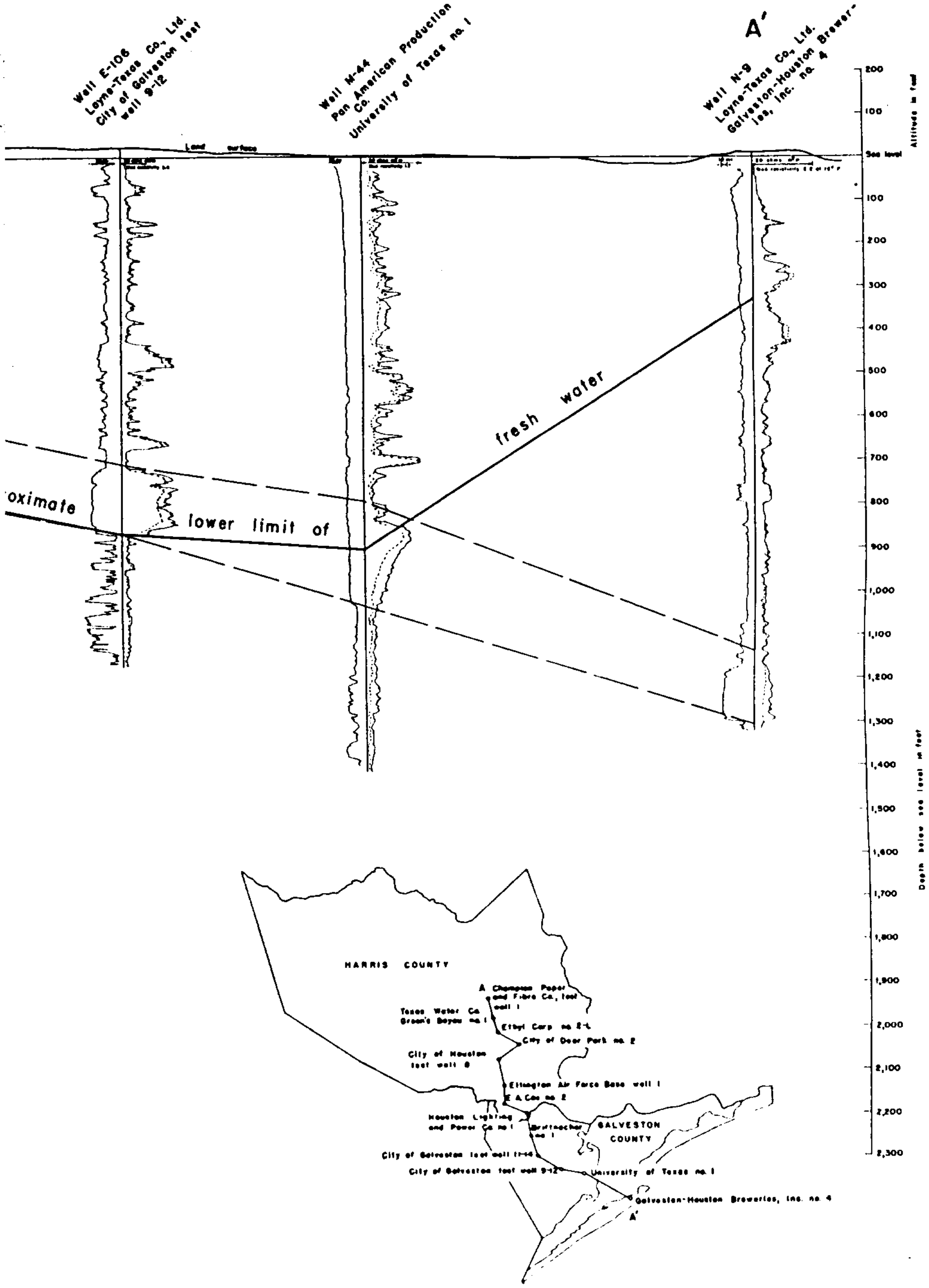


FIGURE 1-3

GEOLOGIC CROSS-SECTION

UPPER GULF COAST

SCALE: AS NOTED | BRE. DWG. NO.: 1K94- | REV. 0

HALLIBURTON NUS
Environmental Corporation

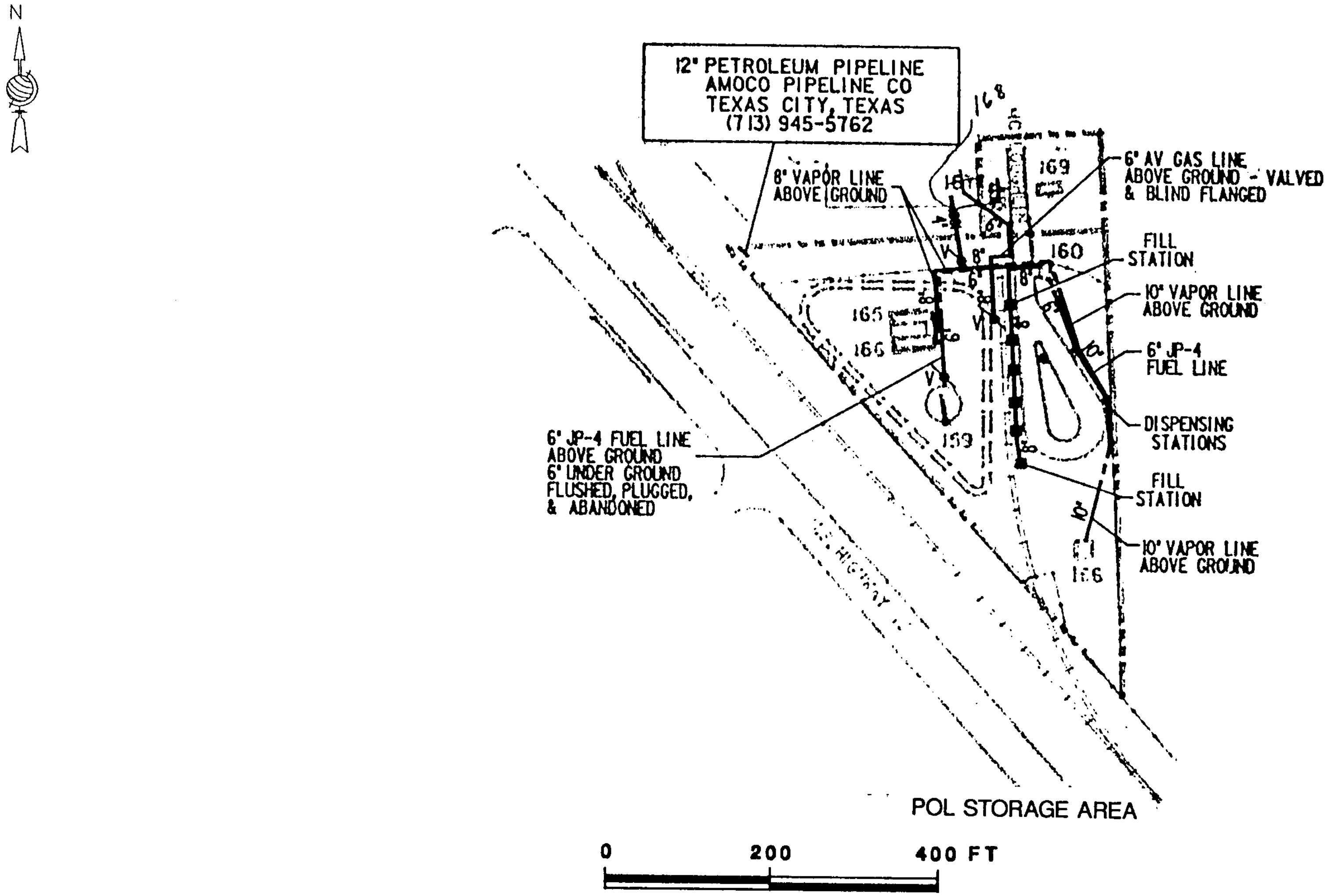
Three above-ground Jet Petroleum Number 4 (JP-4) fuel tanks (Tanks 159, 165 and 166) and a fuel pump station (Building 160) are located at the site (refer to Figure 1-4). The fuel tanks are within a concrete diked area. A cul-de-sac driveway, which allows for refueling tanker trucks, runs north-south between the diked area and the pump station. A railroad spur used for the delivery of JP-4 to the site is situated between the driveway and the diked area. Six fuel feed standpipes are located just east of the railroad spur, with an underground 8-inch diameter fuel loading pipeline leading to the storage tanks.

1.3.2 Site History

A Preliminary Assessment (PA) Records Search was conducted by the Hazardous Materials Technical Center between December 1985 and October 1987 and identified three sites at Ellington Field Air National Guard Base which were potentially contaminated with hazardous materials. Although three sites were identified, only two, the Former Base Landfill and the POL Storage Area, were investigated as part of the subsequent SI. A No Further Action Decision Document was written for the Landfill site. The third site, the Fuel System Repair Shop, was separately assessed, and a Decision Document was written for the site. A discussion of the results of the SI for the POL Storage Area is presented in Section 3.0

A 1973 incident at the POL Storage Area resulted in the release of 8,000 gallons of JP-4 into the shallow drainage ditch over the period of one weekend. The shallow drainage ditch runs outside of the POL Storage Area between the western property fence line and the railroad track. This ditch drains in a northwesterly direction into Horsepen Bayou. Figure 1-5 depicts the drainage ditch and drainage direction. Water that had collected in the storage tank sump was being pumped into the drainage ditch. The pump was inadvertently left on and fuel was allowed to discharge into the ditch. Although attempts were made to contain the spill, most of the fuel reached Horsepen Bayou. No documentation of regulatory involvement in spill reporting, containment or countermeasure activities has been found regarding this incident.

On August 19, 1989, JP-4 was found to be seeping into Horsepen Bayou through and over its south bank, adjacent to the railroad spur at the site. Fuel was collected from the bayou with absorbent booms. Approximately 1700 cubic yards of fill and ballast were removed before interim remedial activities were suspended.



DRAWN BY:	J. TRAN	FIGURE 1-4 PIPING DIAGRAM POL STORAGE AREA ELLINGTON FIELD, HOUSTON, TEXAS	HALLIBURTON NUS *Environmental Corporation*
DATE:	04/19/94		
ENGINEER:	L. BASILIO		
DATE:	04/19/94		
CAD DWG. NO:	ELLING1.DWG	SCALE: 1"=200'	NUS DWG. NO. 1K94-	REV. 0	

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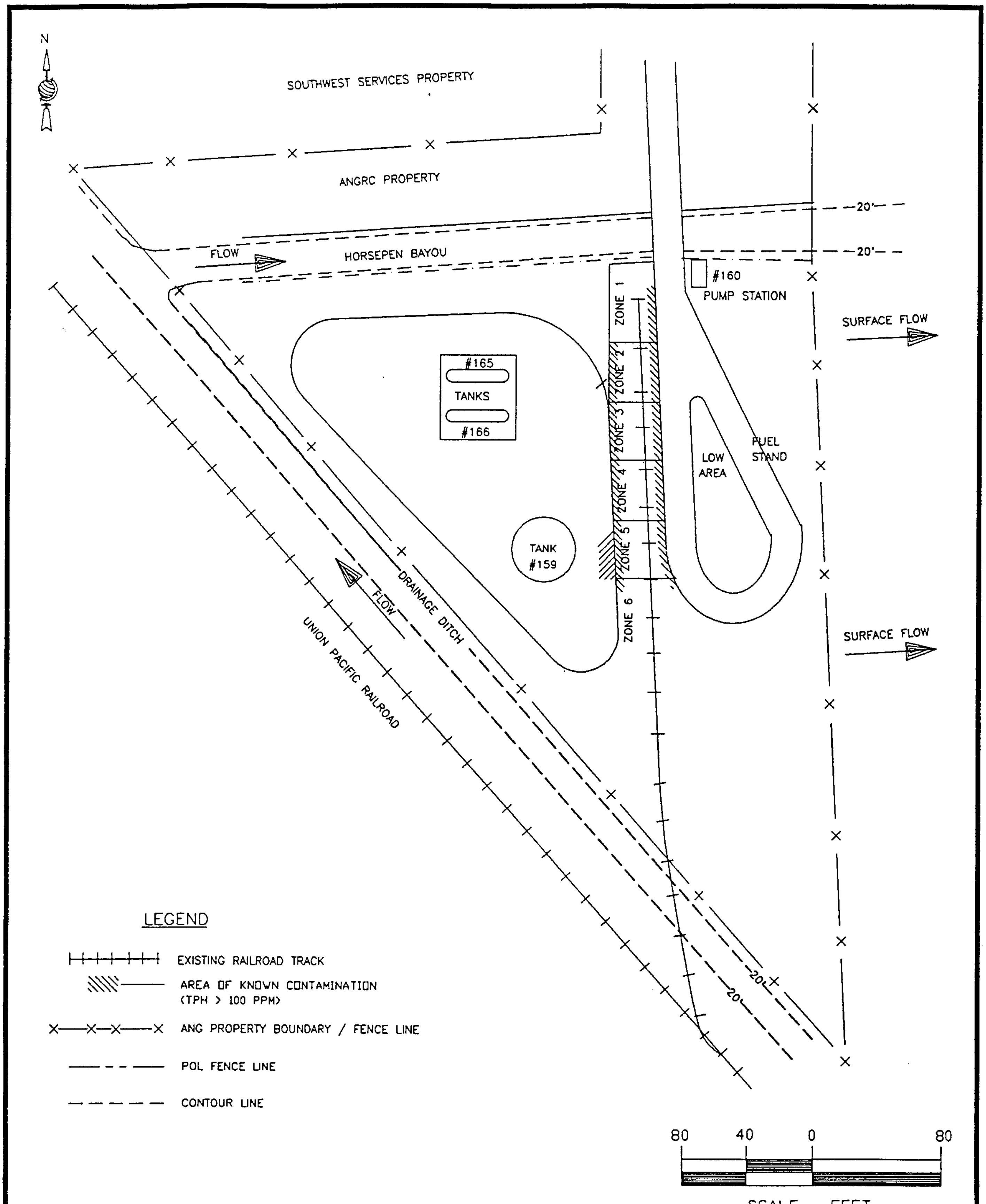


FIGURE 1-5

DRAWN BY:	D. GROSSHANDLER
DATE:	11/10/93
ENGINEER:	L. BASILIO
DATE:	11/10/93
CAD DWG. NO:	1K942A02.DWG

TPH CONCENTRATIONS
IN EXCESS OF 100 ppm
POL STORAGE AREA
ELLLINGTON FIELD (ANGRC)

SCALE: 1"=80' | DWG. NO. 1K94-2A02 | REV. 0

HALLIBURTON NUS Environmental Corporation

1K942A02.DWG/LKB/09-22-94

Excavated material was transported to and disposed of in Class I and Class II non-hazardous landfills. Although the majority of the contaminated materials were removed, remedial efforts required to excavate all materials contaminated above TNRCC guidelines were not completed due to budgetary considerations and uncertainty about the possible extent of contamination. TNRCC requirements to achieve clean closure are excavation and removal of all soils containing concentrations of total petroleum hydrocarbons (TPH) greater than 100 ppm and the sum total of benzene, toluene, ethylbenzene, and xylene (BTEX) greater than 30 ppm. Figure 1-5 depicts areas where laboratory results indicate the presence of total petroleum hydrocarbons in soils at concentrations greater than 100 ppm as ascertained during the 1989 remedial activities.

Once the remedial efforts were halted, the trench was backfilled and compacted and the railroad tracks replaced. A report on these activities (Report on POL Remediation Activities at Ellington Field Air National Guard Base, NUS Report Number R-34-10-0-002H) was issued to the ANGRC and the TNRCC in November 1989.

1.4 Report Organization

Section ES of this report presents an executive summary.

Section 1.0 presents an introductory discussion of the objectives of IRP, a brief description of the environmental setting of Ellington Field, a description of the POL Storage Area, a brief history of investigative activities, findings, remedial actions, and the organization of this report.

Section 2.0 presents the data from the SI conducted at the POL Storage Area.

Section 3.0 discusses project activities performed during the course of the SC at the POL Storage Area.

Section 4.0 consists of an evaluation of the geologic, hydrogeologic, and laboratory analytical data generated during the SC.

Section 5.0 presents the summary and conclusions derived from the SC.

Section 6.0 presents the reccomendations of this report.

Section 7.0 presents references.

2.0 SITE INVESTIGATION RESULTS

In 1989/1990 a Site Investigation (SI) was conducted by Halliburton NUS. The purpose of the SI was to confirm the presence or absence of contamination at the site. Two sites were evaluated as part of the SI, the Former Base Landfill and the POL Storage Area. Specific elements of the SI included the drilling of soil borings, the installation of piezometers and monitoring wells, collection of environmental samples, aquifer testing, chemical laboratory analysis, risk assessment, data evaluation and report preparation.

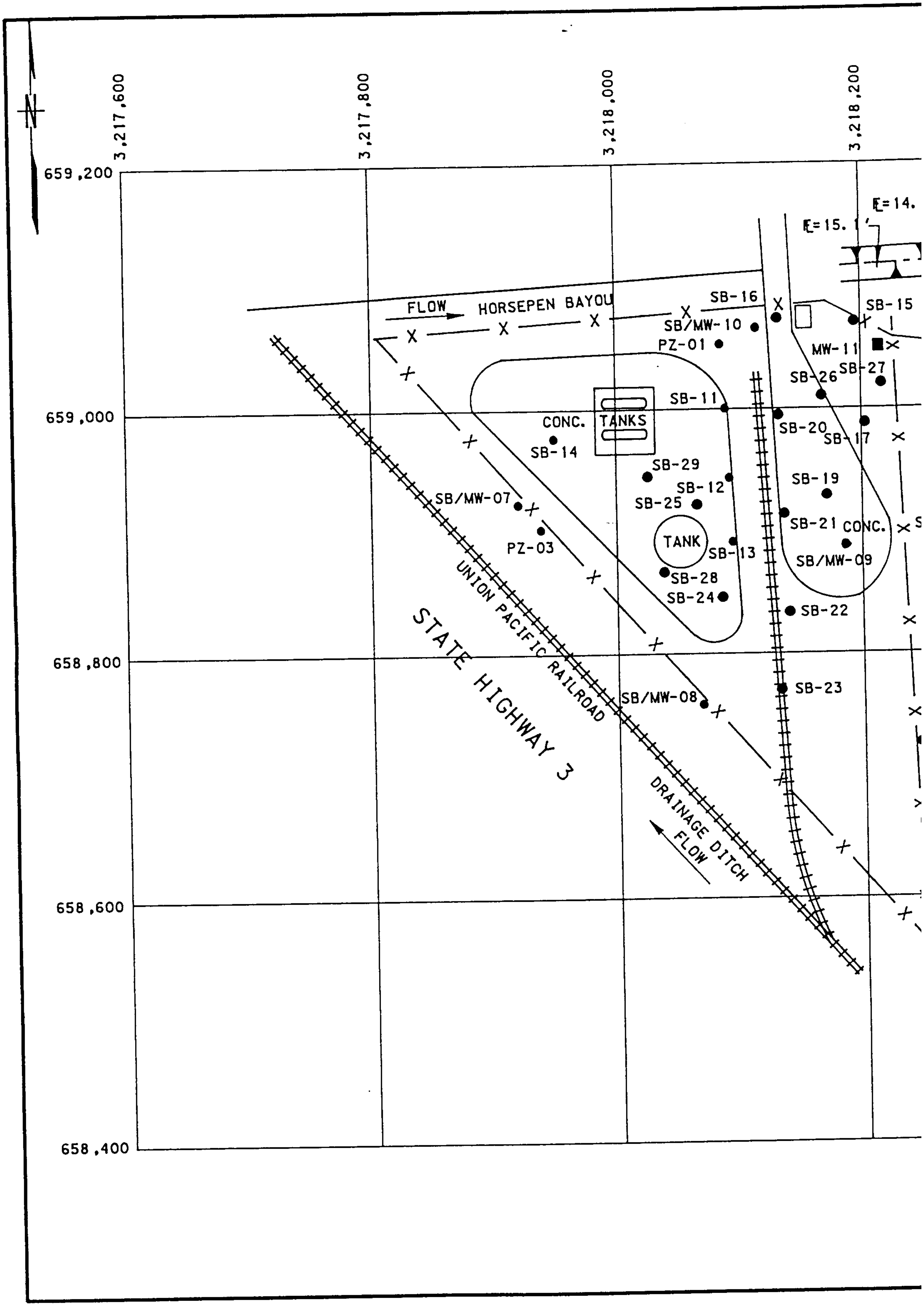
In the soil samples collected from the POL Storage Area, several volatile and two semi-volatile compounds were detected beneath the diked area and adjacent to the railroad track in Soil Borings SB-10, SB-13, and SB-14 (Figure 2-1) in the range of 1 ug/kg to 13,000 ug/kg. The results of the SI soil analyses are summarized in Table 2-1.

Four volatiles in the range of 6 ug/l to 23 ug/l were detected in a groundwater sample collected from Monitoring Well MW-10 at the POL Storage Area. It should be noted that all values were below Maximum Contaminant Levels (MCL). The results of the SI groundwater analyses are summarized in Table 2-2.

A baseline risk assessment was also performed as part of the SI. The risk assessment concluded that no significant risks to human health appear to exist at the POL Storage Area based upon the SI results only.

On October 3, 1990 a meeting was held between representatives of ANGRC, HAZWRAP, and Halliburton NUS at Ellington Field Air National Guard Base. In the meeting the results of the SI were discussed. Based on this meeting it was decided that additional investigation of the POL Storage Area was required. In general terms, the scope of work necessary to determine the extent of environmental contamination discovered at the site was agreed upon. The SC expanded on the SI by following up on areas which appeared impacted based on the SI results (i.e., the area beneath the dike and the area east of the railroad track). The SC would also study areas not investigated during the SI (i.e., the fuel stand areas and the pump house area).

On January 4, 1991, the final project report (Site Investigation Report, Halliburton NUS Report R-48-05-0-016H) was issued.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TANKS
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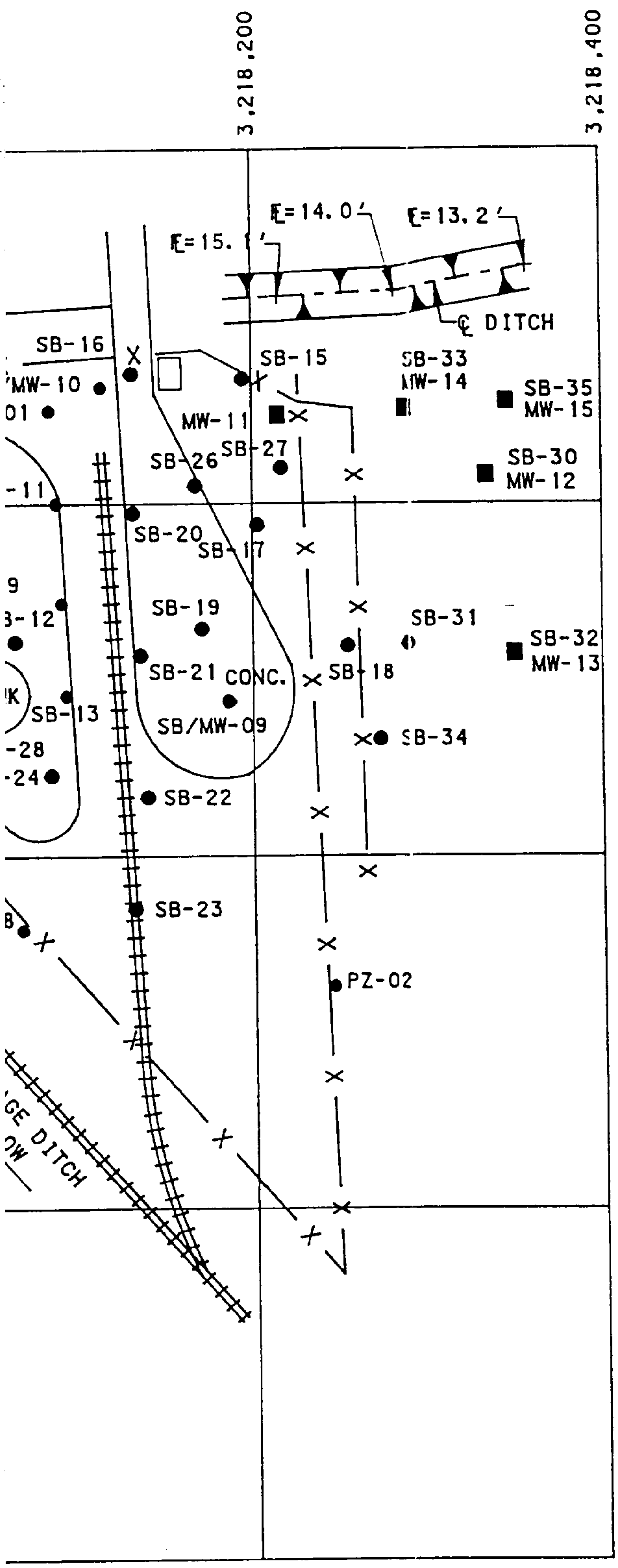
CONC.
TANK
PZ-03
SB-13
SB/MW-09
SB-28
SB-24
SB-22
UNION PACIFIC RAILROAD
STATE HIGHWAY 3
SB-23
SB/MW-08
DRAINAGE DITCH
FLOW



POINT NUMBER	TEXAS PLANE COORDINATES SOUTH CENTRAL ZONE NORTHING	EASTING	TOP OF CASING (PVC PIPE
MW-11	659,049.99	3,218,214.73	28.31
SB-15	659,070.46	3,218,194.84	
SB-16	659,076.67	3,218,131.41	
SB-17	658,987.90	3,218,202.84	
SB-18	658,919.21	3,218,254.28	
SB-19	658,929.26	3,218,170.92	
SB-20	658,994.85	3,218,132.13	
SB-21	658,914.15	3,218,136.01	
SB-22	658,833.89	3,218,139.60	
SB-23	658,770.22	3,218,131.90	
SB-24	658,846.48	3,218,085.31	
SB-25	658,922.17	3,218,065.48	
SB-26	659,010.33	3,218,167.85	
SB-27	659,020.19	3,218,216.74	
SB-28	658,867.37	3,218,038.28	
SB-29	658,945.57	3,218,025.47	
SB-30/MW-12	659,015.64	3,218,335.30	23.14
SB-31	658,920.39	3,218,290.10	
SB-32/MW-13	658,914.99	3,218,350.44	23.11
SB-33/MW-14	659,053.59	3,218,288.39	23.99
SB-34	658,866.38	3,218,272.98	
SB-35/MW-15	659,057.18	3,218,346.67	23.45

NOTES:

1. ALL ELEVATIONS SHOWN HEREON ARE BASED ON NGS BENC M-1276 WITH ELEVATION OF 24.52 FEET, NGVD 1929 DA 1987 ADJUSTMENT.
2. ALL COORDINATES ARE REFERENCED TO THE TEXAS COORD SOUTH CENTRAL ZONE AND ARE BASED ON U.S.C. & G.S. MARKER ELLINGTON 1952 HAVING COORDINATES OF NORTH EAST: 3,215,019.21 WITH A GRID FACTOR OF 0.99987
3. MONITOR WELLS MW-07 THROUGH MW-10 AND SOIL BORIN THROUGH SB-14 WERE INSTALLED IN JANUARY 1990 DUR

LEGEND:

■ MW = MONITOR WELL
● SB = SOIL BORING
NG = NATURAL GROUND
CONC. = CONCRETE

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MAP SH
LOCATIONS AND
MONITORING WELLS
AT THE POL ST
ELLINGTON F
HOUSTON

SURVEYED BY: JDC
DRAWN BY: D. GROSSHANDLER
CHECKED BY: L. BASILIO

POINT NUMBER	TEXAS PLANE COORDINATES SOUTH CENTRAL ZONE NORTHING	EASTING	ELEVATIONS TOP OF CASING (PVC PIPE)	TOP OF CONCRETE OR NATURAL GROUND	
MW-11	659,049.99	3,218,214.73	28.31	25.84	(NG)
SB-15	659,070.46	3,218,194.84		25.56	(NG)
SB-16	659,076.67	3,218,131.41		25.54	(CONC)
SB-17	658,987.90	3,218,202.84		25.41	(NG)
SB-18	658,919.21	3,218,254.28		23.61	(NG)
SB-19	658,929.26	3,218,170.92		25.68	(CONC)
SB-20	658,994.85	3,218,132.13		25.61	(CONC)
SB-21	658,914.15	3,218,136.01		25.79	(CONC)
SB-22	658,833.89	3,218,139.60		26.41	(NG)
SB-23	658,770.22	3,218,131.90		26.01	(NG)
SB-24	658,846.48	3,218,085.31		24.25	(CONC)
SB-25	658,922.17	3,218,065.48		23.83	(CONC)
SB-26	659,010.33	3,218,167.85		26.06	(NG)
SB-27	659,020.19	3,218,216.74		25.86	(NG)
SB-28	658,867.37	3,218,038.28		23.98	(CONC)
SB-29	658,945.57	3,218,025.47		23.66	(CONC)
SB-30/MW-12	659,015.64	3,218,335.30	23.14	23.19	(NG)
SB-31	658,920.39	3,218,290.10		23.31	(NG)
SB-32/MW-13	658,914.99	3,218,350.44	23.11	23.47	(NG)
SB-33/MW-14	659,053.59	3,218,288.39	23.99	24.10	(NG)
SB-34	658,866.38	3,218,272.98		23.51	(NG)
SB-35/MW-15	659,057.18	3,218,346.67	23.45	23.90	(NG)

NOTES:

1. ALL ELEVATIONS SHOWN HEREON ARE BASED ON NGS BENCHMARK M-1276 WITH ELEVATION OF 24.52 FEET, NGVD 1929 DATUM, 1987 ADJUSTMENT.
2. ALL COORDINATES ARE REFERENCED TO THE TEXAS COORDINATE SYSTEM, SOUTH CENTRAL ZONE AND ARE BASED ON U.S.C. & G.S. SURVEY MARKER ELLINGTON 1952 HAVING COORDINATES OF NORTH: 662,268.83, EAST: 3,215,019.21 WITH A GRID FACTOR OF 0.9998723.
3. MONITOR WELLS MW-07 THROUGH MW-10 AND SOIL BORINGS SB-11 THROUGH SB-14 WERE INSTALLED IN JANUARY 1990 DURING THE SI.

FIGURE 2-1

HALLIBURTON NUS
Environmental Corporation

MAP SHOWING
LOCATIONS AND ELEVATIONS OF
MONITORING WELLS & SOIL BORINGS
AT THE POL STORAGE AREA
ELLINGTON FIELD (ANG.)
HOUSTON, TEXAS

LEGEND:

■ MW = MONITOR WELL
● SB = SOIL BORING
NG = NATURAL GROUND
CONC. = CONCRETE

SURVEYED BY: JDC	SCALE: 1" = 100'
DRAWN BY: D. GROSSHANDLER	DATE: 09-10-93
CHECKED BY: L. BASILIO	JOB NO.: NQ-1K94-BB

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TABLE 2-1

CONCENTRATIONS OF ANALYTES DETECTED IN SUBSURFACE SOIL DURING SI (1989)(1)(2) POL STORAGE AREA ELLINGTON FIELD AIR NATIONAL GUARD BASE

Sample Number Sample Depth Sample Date	Clean Up Level(3)	02-SB10A-A 8'-10' 1/16/90	02-FD04-A Duplicate of 02-SB10A-A	02-SB13A-A 0'-2' 12/19/89	02-SB13B-A 4'-6' 12/19/89	02-SB13C-A 20'-22' 12/19/89	02-SB14A-A 0'-2' 12/19/89
Volatiles (ug/kg)							
Acetone	NA			160			250 J
2-Butanone	NA						40 J
4-Methyl-2-Pentanone	NA					4 J	
Benzene	(4)			180 J	13,000 J	3 J	
Ethylbenzene	(4)	66 J		210 J	13,000 J	3 J	
Total Xylenes	(4)			240 J		12 J	
Styrene	NA					5 J	
Chlorobenzene	NA					1 J	
Methylene Chloride	NA				6,100 J		
1,2- Dichloropropane	NA					1 J	
Base/Neutrals (ug/kg)							
Naphthalene	NA		110 J		200 J		
2-Methylnaphthalene	NA	150 J	340 J		640		
Geochemical Parameters (mg/kg)							
Total Petroleum Hydrocarbons	100	99	99	132			

NA - Not applicable
(1) No entry indicates parameter not detected above Contract Required Quantitation Limit
(2) J lab qualifier indicating estimated value.
(3) TNRCC, Guidance Manual For LPST Cleanups in Texas, January 1990
(4) Standard is 30000 ug/kg total BTEX.

TABLE 2-2
CONCENTRATIONS OF ANALYTES DETECTED IN GROUNDWATER DURING SI
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Sample Number Sample Date	Cleanup Standard (2)	02-MW10-A(1) 1/22/90
Volatiles (ug/L)		
Ethylbenzene	100(3)	6 J
Total Xylenes	100(3)	23 J
Styrene	100(4)	10 J
Chlorobenzene	100(4)	6 J

Notes

(1) J qualifier indicates estimated results.

(2) Standards reflect most stringent TNRCC Group 1 impacted groundwater cleanup standards. These standards may not represent actual conditions at site and are used for comparison only.

(3) TNRCC, Guidance Manual for LPST cleanups in Texas, January 1990. Standard is 100 ppb total BTEX.

(4) Maximum contaminant level, 56 Federal Register 3526-3597.

3.0 FIELD PROGRAM

3.1 Site Characterization

3.1.1 Summary

The objective of the SC performed at the Ellington Field Air National Guard Base POL Storage Area was to:

> acquire additional data, as necessary, to define the extent of confirmed environmental contamination by further characterization of the subsurface stratigraphy, aquifer properties and contamination migration pathways.

Activities performed during the SC included the following:

- Drilling and sampling of 22 soil borings (12 Initial Phase and 10 Optional Phase).
- Installation of 5 monitoring wells (1 Initial Phase and 4 Optional Phase).
- Collection of 72 subsurface soil samples (65 samples plus 7 duplicates) and 9 groundwater samples for fixed base laboratory analysis.
- Measurement of water levels in all nine groundwater monitoring wells at the site.
- In-situ hydraulic conductivity testing of the 5 monitoring wells installed during the SC.

3.1.2 Deviations From Work Plan

Deviations from the Work Plan during the field investigation of the POL Storage Area were as follows:

- Hand auger borings and sampling in the creek bank of Horsepen Bayou were not performed. In the interim time period between formulation of the sampling program and initiation of field activities, a concrete surface was constructed over the creek bank.

- The hexane rinse was deleted from the decontamination procedures as requested by Energy Systems.

- Slotted augers were not employed for drilling in order to minimize contact between groundwater and impacted shallow soils.

- The hollow stem augers were purged using a submersible pump instead of a PVC bailer.

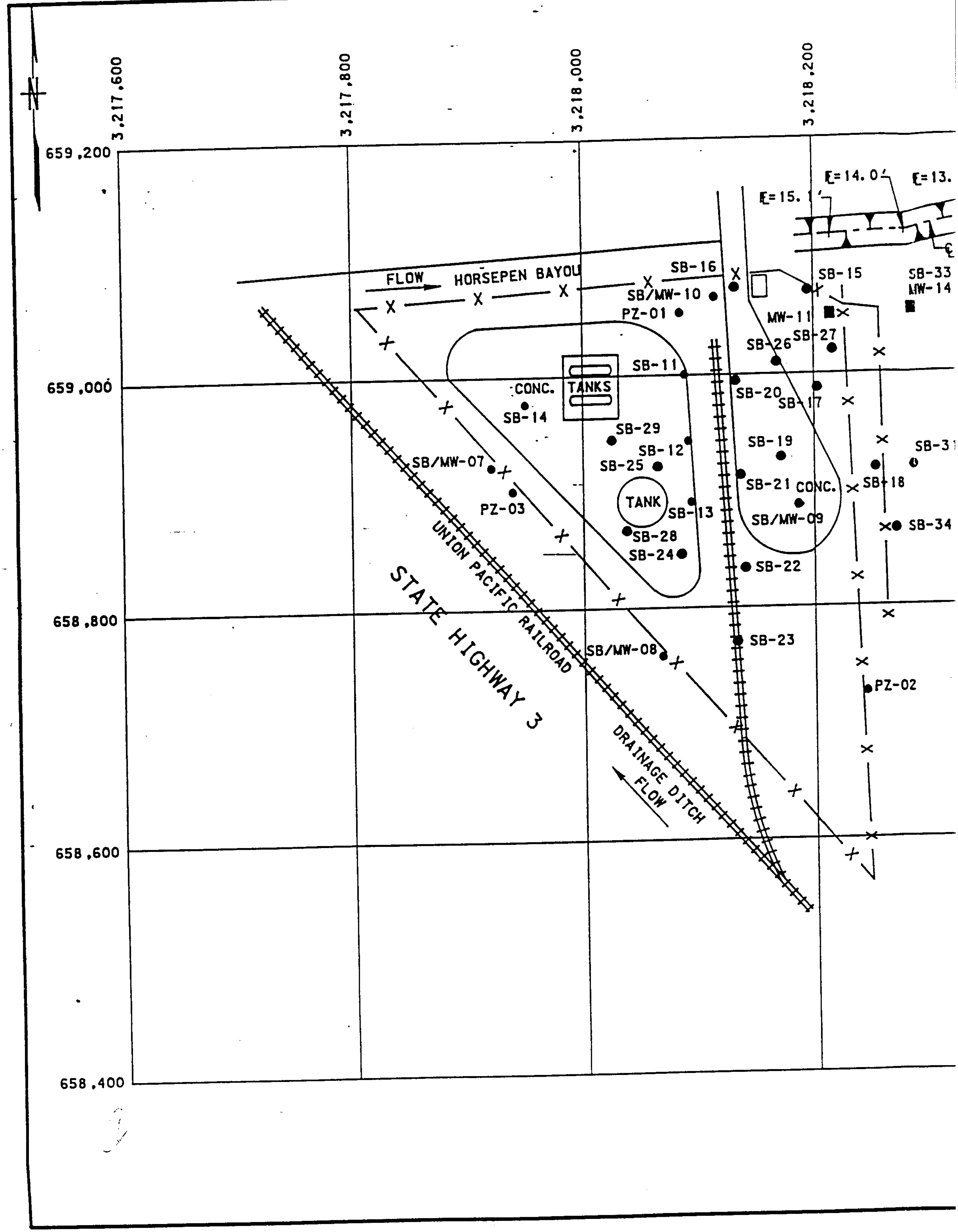
3.2 Geologic and Hydrogeologic Investigations

In order to achieve the project objective described in Section 1.0, 22 soil borings were drilled and 5 monitoring wells were installed at the locations shown on Figure 3-1. An overview of the geologic and hydrogeologic investigations is presented below.

3.2.1 Geologic Investigation

Twenty two soil borings (SB-15 through SB-35 and MW-11) were drilled at the POL Storage Area as part of the SC. Five of these borings were subsequently completed as monitoring wells. Samples were continuously collected from each of the soil borings. A portable field gas chromatograph (GC) was employed at the site to screen soil samples.

A total of 72 subsurface soil samples (65 samples plus 7 duplicates) were collected for fixed base laboratory analysis. A minimum of two and a maximum of three samples were collected from each boring. One sample was generally collected at the 0-2 foot interval and one sample collected at the interface of the saturated and unsaturated zones. An intermediate depth sample was collected if field evidence of contamination was noted. A groundwater sample was also collected from each soil boring and analyzed using the field GC. Soil samples were



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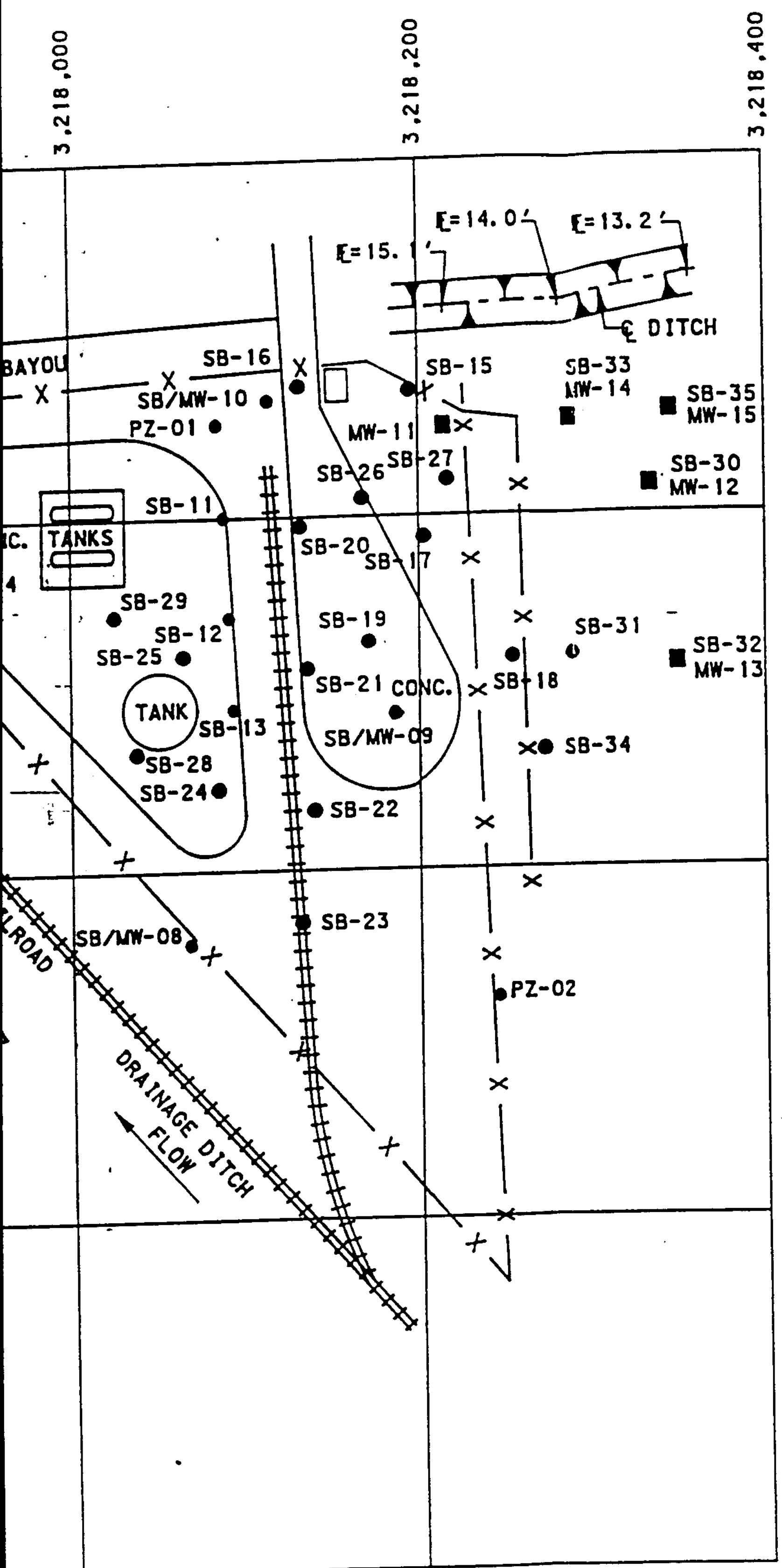
SB-23
PZ-02
DRAINAGE DITCH
FLOW



POINT NUMBER	TEXAS PLANE COORDINATES SOUTH CENTRAL ZONE NORTHING	EASTING
MW-11	659,049.99	3,218,214.73
SB-15	659,070.46	3,218,194.84
SB-16	659,076.67	3,218,131.41
SB-17	658,987.90	3,218,202.84
SB-18	658,919.21	3,218,254.28
SB-19	658,929.26	3,218,170.92
SB-20	658,994.85	3,218,132.13
SB-21	658,914.15	3,218,136.01
SB-22	658,833.89	3,218,139.60
SB-23	658,770.22	3,218,131.90
SB-24	658,846.48	3,218,085.31
SB-25	658,922.17	3,218,065.48
SB-26	659,010.33	3,218,167.85
SB-27	659,020.19	3,218,216.74
SB-28	658,867.37	3,218,038.28
SB-29	658,945.57	3,218,025.47
SB-30/MW-12	659,015.64	3,218,335.30
SB-31	658,920.39	3,218,290.10
SB-32/MW-13	658,914.99	3,218,350.44
SB-33/MW-14	659,053.59	3,218,288.39
SB-34	658,866.38	3,218,272.98
SB-35/MW-15	659,057.18	3,218,346.67

NOTES:

1. ALL ELEVATIONS SHOWN HEREON ARE BASEI M-1276 WITH ELEVATION OF 24.52 FEET, 1987 ADJUSTMENT.
2. ALL COORDINATES ARE REFERENCED TO THI SOUTH CENTRAL ZONE AND ARE BASED ON MARKER ELLINGTON 1952 HAVING COORDIN EAST: 3,215,019.21 WITH A GRID FACTO
3. MONITOR WELLS MW-07 THROUGH MW-10 ANI THROUGH SB-14 WERE INSTALLED IN JANU

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- ■ MW = MONITOR WELL
- ● SB = SOIL BORING
- NG = NATURAL GROUND
- CONC. = CONCRETE

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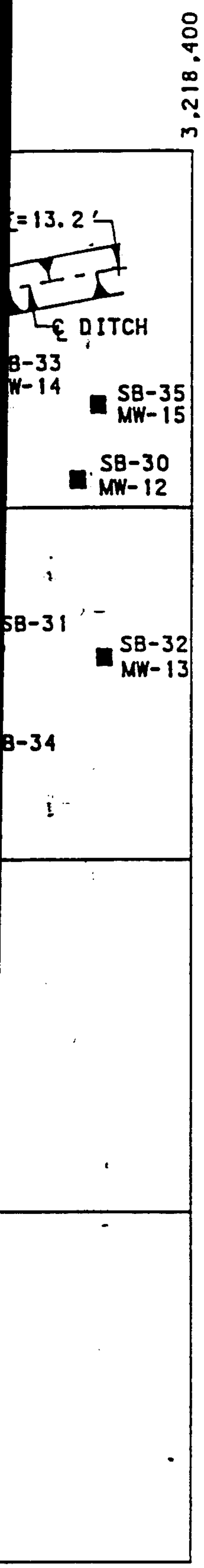


POINT NUMBER	TEXAS PLANE COORDINATES SOUTH CENTRAL ZONE		ELEVATIONS		
	NORTHING	EASTING	TOP OF CASING (PVC PIPE)	TOP OF CONCRETE OR NATURAL GROUND	
MW-11	659,049.99	3,218,214.73	28.31	25.84	(NG)
SB-15	659,070.46	3,218,194.84		25.56	(NG)
SB-16	659,076.67	3,218,131.41		25.54	(CONC)
SB-17	658,987.90	3,218,202.84		25.41	(NG)
SB-18	658,919.21	3,218,254.28		23.61	(NG)
SB-19	658,929.26	3,218,170.92		25.68	(CONC)
SB-20	658,994.85	3,218,132.13		25.61	(CONC)
SB-21	658,914.15	3,218,136.01		25.79	(CONC)
SB-22	658,833.89	3,218,139.60		26.41	(NG)
SB-23	658,770.22	3,218,131.90		26.01	(NG)
SB-24	658,846.48	3,218,085.31		24.25	(CONC)
SB-25	658,922.17	3,218,065.48		23.83	(CONC)
SB-26	659,010.33	3,218,167.85		26.06	(NG)
SB-27	659,020.19	3,218,216.74		25.86	(NG)
SB-28	658,867.37	3,218,038.28		23.98	(CONC)
SB-29	658,945.57	3,218,025.47		23.66	(CONC)
SB-30/MW-12	659,015.64	3,218,335.30	23.14	23.19	(NG)
SB-31	658,920.39	3,218,290.10		23.31	(NG)
SB-32/MW-13	658,914.99	3,218,350.44	23.11	23.47	(NG)
SB-33/MW-14	659,053.59	3,218,288.39	23.99	24.10	(NG)
SB-34	658,866.38	3,218,272.98		23.51	(NG)
SB-35/MW-15	659,057.18	3,218,346.67	23.45	23.90	(NG)

NOTES:

1. ALL ELEVATIONS SHOWN HEREON ARE BASED ON NGS BENCHMARK M-1276 WITH ELEVATION OF 24.52 FEET, NGVD 1929 DATUM, 1987 ADJUSTMENT.
2. ALL COORDINATES ARE REFERENCED TO THE TEXAS COORDINATE SYSTEM, SOUTH CENTRAL ZONE AND ARE BASED ON U.S.C. & G.S. SURVEY MARKER ELLINGTON 1952 HAVING COORDINATES OF NORTH: 662,268.83, EAST: 3,215,019.21 WITH A GRID FACTOR OF 0.9998723.
3. MONITOR WELLS MW-07 THROUGH MW-10 AND SOIL BORINGS SB-11 THROUGH SB-14 WERE INSTALLED IN JANUARY 1990 DURING THE SI.

LEGEND:

- ■ MW = MONITOR WELL
- ● SB = SOIL BORING
- NG = NATURAL GROUND
- CONC. = CONCRETE

FIGURE 3-1

HALLIBURTON NUS
Environmental Corporation

MAP SHOWING
LOCATIONS AND ELEVATIONS OF
MONITORING WELLS & SOIL BORINGS
AT THE POL STORAGE AREA
ELLINGTON FIELD (ANG.)
HOUSTON, TEXAS

SURVEYED BY: JDC	SCALE: 1" = 100'
DRAWN BY: D. GROSSHANDLER	DATE: 09-10-93
CHECKED BY: L. BASILIO	JOB NO.: NQ-1K94-BB

 HOU07US - /USR19A/HCIVIL/910333/NQ1K94BB.DGN-02

analyzed for total petroleum hydrocarbons (TPH) and benzene, toluene, ethylbenzene, and xylene (BTEX). Five soil samples were also analyzed for Target Compound List (TCL) volatiles and TCL Base Neutrals/Acid Extractables (BNA). These samples were selected to provided data for future risk assessment activities, should they be deemed appropriate.

Sample locations are shown on Figure 3-1. Table 3-1 is a summary of laboratory analyses performed on the subsurface soil samples.

3.2.2 Hydrogeologic Investigation

Five monitoring wells were installed at the POL Storage Area, beyond the leading edge of the plume in order to define the extent of groundwater contamination. Water level measurements were collected from these five monitoring wells in addition to the four existing monitoring wells at the site. Prior to installation of the monitoring wells, water levels readings were collected from the four existing monitoring wells at the site. A groundwater elevation contour map was constructed in the field to confirm groundwater flow direction as determined in the SI. Groundwater flow direction was found to be easterly and in agreement with the SI results. Groundwater samples were collected from all nine monitoring wells for analysis at a fixed base laboratory. Groundwater samples were analyzed for TPH, BTEX, TCL volatiles, TCL BNA, or total dissolved solids (TDS). Monitoring Wells MW-07, MW-10 and MW-11 were analyzed for TPH, TCL volatiles, TCL semivolatiles, and TDS. These three monitoring wells were selected for an expanded analytical analyses. Monitoring Well MW-07 was selected because it is situated upgradient of the site. Monitoring Well MW-10 was selected because analytical results from the SI indicated possible hydrocarbon impact. Monitoring Well MW-11 was selected because it was best situated to detect any contaminants which may have migrated downgradient from Monitoring Well MW-10. The remaining monitoring wells were all analyzed for TPH and BTEX only. In-situ permeability testing was performed on the five recently installed monitoring wells to determine hydraulic properties of the shallow aquifer beneath the site.

Groundwater monitoring sample locations are shown on Figure 3-1. Table 3-2 presents a summary of laboratory analyses of groundwater samples collected.

TABLE 3-1

MATRIX OF LABORATORY ANALYSES PERFORMED ON SOIL SAMPLES
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Sample ID	Soil Boring	Sample Depth (Feet)	TPH	BTEX	TCL VOA	TCL BNA
02-SB15-A-A	SB-15	0-2	X			
02-SB15-B-A	SB-15	12-14	X			
02-SB15-C-A	SB-15	20-22	X			
02-SB16-A-A	SB-16	4-6	X	X		
02-SB16-B-A	SB-16	8-10	X		X	X
02-SB16-C-A	SB-16	20-22	X	X		
02-SB17-A-A	SB-17	2-4	X	X		
02-SB17-B-A	SB-17	8-10	X	X		
02-SB17-C-A	SB-17	22-24	X	X		
02-SB18-A-A	SB-18	0-2	X	X		
02-SB18-B-A	SB-18	10-12	X		X	X
02-SB18-C-A	SB-18	18-20	X	X		
02-SB19-A-A	SB-19	2-4	X		X	X
02-SB19-B-A	SB-19	4-6	X			
02-SB19-C-A	SB-19	20-22	X	X		
02-SB20-A-A	SB-20	2-4	X	X		
02-SB20-B-A	SB-20	4-6	X		X	X
02-SB20-C-A	SB-20	20-22	X	X		
02-SB21-A-A	SB-21	2-4	X	X		
02-SB21-B-A	SB-21	4-6	X	X		
02-SB21-C-A	SB-21	20-22	X	X		
02-SB22-A-A	SB-22	4-6	X	X		
02-SB22-B-A	SB-22	6-8	X	X		
02-SB22-C-A	SB-22	22-24	X	X		

TABLE 3-1 (Continued)

MATRIX OF LABORATORY ANALYSES PERFORMED ON SOIL SAMPLES
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Sample ID	Soil Boring	Sample Depth (Feet)	TPH	BTEX	TCL VOA	TCL BNA
02-SB23-A-A	SB-23	0-2	X	X		
02-SB23-B-A	SB-23	6-8	X	X		
02-SB23-C-A	SB-23	20-22	X	X		
02-SB24-A-A	SB-24	1-3	X	X		
02-SB24-B-A	SB-24	11-13	X	X		
02-SB24-C-A	SB-24	17-19	X	X		
02-SB25-A-A	SB-25	1-3	X	X		
02-SB25-B-A	SB-25	5-7	X	X		
02-SB25-C-A	SB-25	17-19	X	X		
02-SB26-A-A	SB-26	0-2	X	X		
02-SB26-B-A	SB-26	6-8	X		X	X
02-SB26-C-A	SB-26	18-20	X	X		
02-SB27-A-A	SB-27	0-2	X	X		
02-SB27-B-A	SB-27	14-16	X	X		
02-SB27-C-A	SB-27	22-24	X	X		
02-SB28-A-A	SB-28	1-3	X	X		
02-SB28-B-A	SB-28	7-9	X	X		
02-SB28-C-A	SB-28	20-22	X	X		
02-SB29-A-A	SB-29	1-3	X	X		
02-SB29-B-A	SB-29	5-7	X	X		
02-SB29-C-A	SB-29	17-19	X	X		
02-SB30-A-A	SB-30	0-2	X	X		
02-SB30-B-A	SB-30	8-10	X	X		
02-SB30-C-A	SB-30	16-18	X	X		
02-SB31-A-A	SB-31	0-2	X	X		
02-SB31-B-A	SB-31	10-12	X	X		
02-SB31-C-A	SB-31	16-18	X	X		

TABLE 3-1 (Continued)

MATRIX OF LABORATORY ANALYSES PERFORMED ON SOIL SAMPLES
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Sample ID	Soil Boring	Sample Depth (Feet)	TPH	BTEX	TCL VOA	TCL BNA
02-SB32-A-A	SB-32	0-2	X	X		
02-SB32-B-A	SB-32	8-10	X	X		
02-SB32-C-A	SB-32	16-18	X	X		
02-SB33-A-A	SB-33	0-2	X	X		
02-SB33-B-A	SB-33	12-14	X	X		
02-SB33-C-A	SB-33	16-18	X	X		
02-SB34-A-A	SB-34	0-2	X	X		
02-SB34-B-A	SB-34	14-16	X	X		
02-SB34-C-A	SB-34	16-18	X	X		
02-SB35-A-A	SB-35	0-2	X	X		
02-SB35-B-A	SB-35	16-18	X	X		
02-MW11-A-A	MW-11	0-2	X	X		
02-MW11-B-A	MW-11	14-16	X	X		
02-MW11-C-A	MW-11	18-20	X	X		

X indicates analyses performed

TABLE 3-2

MATRIX OF LABORATORY ANALYSES PERFORMED ON GROUNDWATER SAMPLES
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Sample ID	Monitor Well	TPH	BTEX	TCL VOA	TCL BNA	TDS
02-MW07-A-A	MW-07	X		X	X	X
02-MW08-A-A	MW-08	X	X			
02-MW09-A-A	MW-09	X	X			
02-MW10-A-A	MW-10	X		X	X	X
02-MW11-A-A	MW-11	X		X	X	X
02-MW12-A-A	MW-12	X	X			
02-MW13-A-A	MW-13	X	X			
02-MW14-A-A	MW-14	X	X			
02-MW15-A-A	MW-15	X	X			

X indicates analyses performed

3.2.3 Rationale for Implementation of Soil Borings and Monitoring Wells

The SC of the POL Storage Area was performed in a phased manner, consisting of an Initial Phase and an Optional Phase as described in the approved Field Sampling Plan (FSP), with each set of results being reviewed to meet the objectives of project as stated in the Introduction, Section 1.0. In the Initial Phase, one monitoring well (MW-11) was installed and eleven soil borings (SB-15 through 25) were drilled. The FSP discusses in detail the rationale for selecting Initial Phase boring locations. On the basis of information gathered during the Initial Phase, four monitoring wells were installed and ten soil borings were drilled as part of the Optional Phase. All Optional Phase activities were discussed with and approved by Energy Systems and ANGRC prior to implementation.

The following is a discussion of each Optional Phase boring or monitoring well and the rationale for implementation.

Soil Boring SB-26

Optional Phase Soil Boring SB-26 is located down gradient (i.e., east) of Initial Phase soil boring SB-20. Soil boring SB-20 showed indications of hydrocarbon impact. Indications included highly elevated flame ionization detector/ photoionization detector (FID/PID) readings (878 ppm and 1000+ ppm, respectively), elevated field GC readings (62, 157, 4510, 1486 ug/kg of BTEX, respectively), and olfactory evidence of petroleum hydrocarbons. The field GC also indicated elevated BTEX readings in the groundwater sample collected from the borehole (40, 179, 48, 36 ug/l of BTEX, respectively).

Soil Boring SB-27

Optional Phase soil boring SB-27 is located along the eastern property fence line downgradient (i.e., east) of Optional Phase soil boring SB-26. Soil boring SB-26 showed indications of hydrocarbon impact. Indications included highly elevated FID/PID readings (97 ppm and 1000 ppm, respectively), elevated field GC readings (568, 23786, 1066, 5319 ug/kg of BTEX, respectively), and olfactory evidence of petroleum hydrocarbons. The field GC also indicated BTEX readings in the groundwater sample collected from the borehole (42, 954, 1, and 811 ug/l of BTEX, respectively).

Soil Boring SB-28

Optional Phase soil boring SB-28 is located west of SI soil boring SB-13 (known to be impacted, based on SI results) and west of Initial Phase soil boring SB-24. Soil boring SB-24 showed indications of hydrocarbon impact. Indications included elevated FID readings (150 ppm), elevated field GC readings (6, 22, 396,

943 ug/kg of BTEX, respectively), and olfactory evidence of petroleum hydrocarbons.

Soil Boring SB-29

Optional Phase soil boring SB-29 is located west of Initial Phase soil boring SB-25. Soil boring SB-25 showed indications of hydrocarbon impact. Indications included elevated FID/PID readings (26 ppm and 100 ppm, respectively), elevated field GC readings (16, 45, 398, 993 ug/kg of BTEX, respectively), and olfactory evidence of petroleum hydrocarbons. The field GC also indicated slightly elevated BTEX readings in the groundwater sample collected from the borehole (4, 72, 3, and <1.8 ug/l of BTEX, respectively).

Soil Boring SB-30/Monitoring Well MW-12

Optional Phase soil boring SB-30/MW-12 is located on City of Houston property, downgradient (i.e., east) of Optional Phase soil boring SB-27. Soil boring SB-27 showed indications of hydrocarbon impact. Indications included elevated FID readings (400 ppm), elevated field GC readings (495, 1052, 431, 1106 ug/kg of BTEX, respectively), and olfactory evidence of petroleum hydrocarbons. The field GC also indicated elevated BTEX readings in the groundwater sample collected from the borehole (114, 73, 218, and 629 ug/l of BTEX, respectively).

Soil Boring 31

Optional Phase soil boring SB-31 is located on City of Houston property, down gradient (i.e., east) of Initial Phase soil boring SB-18 and the fuel stand area. Soil boring SB-18 showed indications of hydrocarbon impact. Indications included elevated FID/PID readings (52 ppm and 200 ppm, respectively), elevated field GC readings (8, 101, 33, 156 ug/kg of BTEX, respectively), and olfactory evidence of petroleum hydrocarbons. The field GC also indicated slightly elevated BTEX readings in the groundwater sample collected from the borehole (7, 27, 7, and 19 ug/l of BTEX, respectively).

Soil Boring 32/Monitoring Well MW-13

Optional Phase soil boring SB-32/MW-13 is located on City of Houston property downgradient (i.e., east) of Optional Phase soil boring SB-31. Soil boring SB-31 showed indications of hydrocarbon impact. Indications included elevated FID/PID readings (5 ppm and 100 ppm, respectively) and elevated field GC readings (1, 140, 1138, 384 ug/kg of BTEX, respectively).

Soil Boring SB-33/Monitoring Well MW-14

Optional Phase soil boring SB-33/MW-14 is located on City of Houston property, downgradient (i.e., east) of Initial Phase monitoring well MW-11. Monitoring well MW-11 showed indications of hydrocarbon impact. Indications included elevated FID/PID readings (208 ppm and 20 ppm, respectively) and elevated field GC readings (11, 72, 5, 20 ug/kg of BTEX, respectively).

Soil Boring SB-34

Optional Phase soil boring SB-34 is located on City of Houston property, southeast of the fuel stand. Soil boring SB-18 (immediately downgradient of the fuel stand) showed indications of hydrocarbon impacts, as previously mentioned. The location for soil boring SB-34 was selected as the best location, based on groundwater flow direction from the fuel stand, to detect possible downgradient hydrocarbon impact.

Soil Boring SB-35/Monitoring Well MW-15

Optional Phase soil boring SB-35/MW-15 is located on City of Houston property downgradient (i.e., east) of SB-33/MW-14. SB-33/MW-14 showed indications of hydrocarbon impact. Indications included elevated FID/PID readings (15 ppm and 120 ppm, respectively) and elevated field GC readings (424, 4482, 349, 1080 ug/kg of BTEX, respectively). The field GC also indicated elevated BTEX readings in the groundwater sample (5, 367, 13, and 29 ug/l of BTEX, respectively).

3.3 Field Procedures

3.3.1 Field Screening

A portable field GC (i.e., a Photovac Model 10S Plus) was employed onsite to screen selected soil and groundwater samples. Analytical parameters by the field GC were BTEX compounds. Detection limits achieved by the field GC for soil and groundwater were approximately one part per billion (ppb). The detection limit varied due to factors such as the relative volatility of the individual constituents in the sample, moisture content, soil porosity, grain size, and constituent adsorption capacity.

Data obtained from the GC provided real-time information which was used to determine soil boring and monitoring well placement in a noncontaminated area and to aid in determining which soil samples would be sent for fixed base laboratory analysis.

Soil samples were initially screened with a photo ionization detector/flame ionization detector (PID/FID) as discussed below in Section 3.3.2. If positive indications of hydrocarbons were detected in a soil sample screened with the PID and FID, the sample was then analyzed using the field GC. A groundwater sample was also collected from each soil boring using a clean, stainless steel bailer and analyzed using the field GC. Appendix A contains a description of the field GC methodology used in performing the field GC screening along with raw and tabulated data.

3.3.1.1 Comparison of Field GC and Fixed-Base Laboratory Results

Forty one soil samples were collected and analyzed by both the field GC and fixed-base laboratory. Table 3-3 depicts the results of the samples.

Forty-one soil samples were collected and analyzed by both the field GC and fixed-base laboratory. One hundred sixty-four laboratory analytical parameters (i.e., benzene, ethylbenzene, toluene, xylene) were reported. Of these, only 29 parameters (18 percent) are considered to show significant difference between field GC and laboratory analytical results. It is therefore concluded that for soil samples, field GC screening and laboratory results may, in general, be considered comparable. When reviewing the data it should be taken into account that the comparison is between semiquantitative Level A data (field GC) and quantitative Level C data (fixed-base laboratory).

For benzene, the field GC and laboratory were in agreement in reporting non-detects (i.e., the field GC reading was less than or equal to the laboratory detection limit) for 28 (68 percent) of the samples. Ten field GC results exceeded the laboratory reported results and three field GC results were lower than the laboratory reported results. Of these 13 samples, four are considered to show significant difference (i.e., greater than an order of magnitude difference between field GC and laboratory results).

For toluene, the field GC and laboratory were in agreement in reporting non-detects (i.e., the field GC reading was less than or equal to the laboratory detection limit) for 19 (46 percent) of the samples. Eighteen field GC results exceeded the laboratory reported results and four field GC results were lower than the laboratory reported results. Of these 22 samples, eight are considered to show significant difference (i.e., greater than an order of magnitude difference between field GC and laboratory results).

For ethylbenzene, the field GC and laboratory were in agreement in reporting non-detects (i.e., the field GC reading was less than or equal to the laboratory

TABLE 3-3

COMPARISON OF FIELD GC VS. LABORATORY DATA
SOIL SAMPLES
POL Storage Area
Ellington Field

Soil Boring	Sample Depth (ft)	Benzene (ug/kg) FGC	Benzene (ug/kg) LAB	Toluene (ug/kg) FGC	Toluene (ug/kg) LAB	Ethylbenzene (ug/kg) FGC	Ethylbenzene (ug/kg) LAB	Xylene (ug/kg) FGC	Xylene (ug/kg) LAB
MW11	14-16	11.6	<5	72.6	<5	5.9	<5	20.9	<5
MW11	18-20	4.3	<5	44.9	<5	<1.9	<5	4.2	<5
16	4-6	<1	<5J	22	33J	103	32J	43	21J
16	8-10	465	<14	463	<14	1817	<14	1536	<14
16	20-22	1	<5	5	<5	15	<5	19	<5
18	0-2	<1	<5	0.1	<5	1	<5	<0.4	<5
18	10-12	8.4	<13	101.8	<13	33.4	<13	156.8	<13
19	2-4	<1.4	<14	1.8	<14	11.9	<14	4.5	<14
19	4-6	<1.4	<5	1.1	<5	<3.6	<5	<2	<5
20	2-4	2	<5	5	<5	5	7.9J	<1	<5
20	8-10	62	<13	157	<13	4510	<13	1486	<13
21	2-4	<1	<5	5	<5J	5	8.8J	14	<5
21	4-6	2	<5	20	<5	3	<5	10	<5
21	4-6	2	<5	20	<5	3	<5	10	<5
22	6-8	<1.4	<5	0.8	<5	<3.6	<5	<2	<5
23	6-8	<1.4	<5	1.3	<5	28.6	16J	72.9	<5
24	1-3	<0.7	<5	0.4	<5	<0.5	<5	<2	<5
24	11-13	6.4	<5	22.4	<5	396.7	<5	943.4	<5
25	1-3	0.9	<5	0.9	<5	10.3	<5	22.2	<5
25	5-7	16.1	<5J	45.2	90J	398.3	700J	993.8	67J
26	6-8	568.4	<13	23786.9	2J	1066	170	5319	43
26	18-20	36.7	180J	352.8	190J	13.3	960J	1275.1	57J
26	18-20	36.7	<5J	352.8	<5J	13.3	11J	1275.1	<5J
27	14-16	495	3000	1052	8000	431	2500	1106	9900
27	22-24	1	<5	16	<5	6	<5	20	<5
28	1-3	<1	<5	5	7.3J	3	<5	12	<5
28	7-9	2	<5	41	7.6J	102	<5	6	<5
29	1-3	55	12J	70	<5	186	25J	302	<5
29	5-7	13	<5	25	<5	26	<5	35	<5
30	8-10	<0.6	<5	1.5	<5	2.5	<5	<1.4	<5
30	16-18	<0.6	<5	0.9	<5	<1.2	<5	<1.4	<5
31	10-12	1.7	24J	140.5	85J	1138.7	250J	384.1	150J
31	16-18	<0.6	<5	<0.5	<5	10.4	<5	6.8	<5
31	16-18	<0.6	<5	<0.5	<5	10.4	<5	6.8	<5
32	16-18	<0.8	<5	<0.8	<5	<1.9	<5	<1.4	<5
32	16-18	<0.8	<5	<0.8	<5	<1.9	<5	<1.4	<5
33	0-2	<0.8	<5	<0.8	<5	<1.9	<5	<1.4	<5
33	12-14	424.4	<5	4482.2	<5	349.9	<5	1080.3	<5
33	16-18	<0.8	<5	115.5	<5	4.3	<5	12.3	<5
34	14-16	0.9	<5	1.4	<5	<1.1	<5	<0.8	<5
34	16-18	<0.5	<5	0.7	<5	<1.1	<5	<0.8	<5

FGC - field GC data
LAB - fixed-base laboratory data
J - data qualifier for estimated data

detection limit) for 17 (41 percent) of the samples. Nineteen field GC results exceeded the laboratory reported results and five field GC results were lower than the laboratory reported results. Of these 24 samples, six are considered to show significant difference (i.e., greater than an order of magnitude difference between field GC and laboratory results).

For xylene, the field GC and laboratory were in agreement in reporting non-detects (i.e., the field GC reading was less than or equal to the laboratory detection limit) for 14 (34 percent) of the samples. Twenty six field GC results exceeded the laboratory reported results and one field GC result was lower than the laboratory reported results. Of these 27 samples, eleven are considered to show significant difference (i.e., greater than an order of magnitude difference between field GC and laboratory results).

Five groundwater samples were collected and analyzed by the field GC and fixed-base laboratory. These results are also shown on Table 3-4. The following comparisons are between a groundwater sample collected from the soil boring and analyzed with the field GC and a groundwater sample collected at a later date from the monitoring well installed in that soil boring and analyzed by the fixed-base laboratory.

For monitoring well MW-11, the field GC and laboratory were in agreement in reporting non-detects (i.e., the field GC reading was less than or equal to the laboratory detection limit) for benzene, ethylbenzene and xylene. The field GC reported a concentration of toluene at 27.8 ug/l while the laboratory reported non-detect.

For monitoring well MW-12, the field GC and laboratory were in agreement in reporting non-detects (i.e., the field GC reading was less than or equal to the laboratory detection limit) for benzene and toluene. Ethylbenzene and xylene were also reported as non-detect by both field GC and laboratory analyses but the reporting limits for the field GC (<1.5 and <1.9 ug/l, respectively) are slightly above the detection limit for the laboratory (1 ug/l). The results for this sample between the field GC and laboratory can therefore be considered comparable.

For monitoring well MW-13, the results were the same as MW-12. The field GC and laboratory were in agreement in reporting non-detects for benzene and toluene. Ethylbenzene and xylene were also reported as non-detect by both field GC and laboratory analyses but the reporting limits for the field GC (<3.2 and <2.4 ug/l, respectively) are slightly above the detection limit for the laboratory (1 ug/l). The results for this sample between the field GC and laboratory can therefore be considered comparable.

TABLE 3-4
COMPARISON OF FIELD GC VS. LABORATORY DATA
GROUNDWATER SAMPLES
POL Storage Area
Ellington Field

	FGC	LAB	FGC	LAB	FGC	LAB	FGC	LAB
Monitor Well	**Benzene (ug/kg)**		**Toluene (ug/kg)**		**Ethylbenzene (ug/kg)**		**Xylene (ug/kg)**	
11	<1.5	<10	27.8	<10	<1.8	<10	<2.3	<10
30	<0.7	<1	0.8	<1	<1.5	<1	<1.9	<1
32	<1	<1	<0.7	<1	<3.2	<1	<2.4	<1
33	4.7	<1	367.4	<1	12.6	<1	29.1	<1
35	<5	<1	<5	<1	<5	<1	<5	<1

FGC - field GC data
LAB - fixed-base laboratory data

Monitoring well MW-14 exhibits the largest divergence between the field GC and laboratory analytical results. The laboratory reported non-detects for all parameters. The field GC reported BTEX at 5, 367, 12, and 29 ug/l, respectively.

For monitoring well MW-15 the laboratory and field GC both reported non-detect. The detection limit of the field GC was higher than the laboratory (5 ug/l versus 1 ug/l, respectively).

With the exception of monitoring well MW-14, the results of the field GC and laboratory analyses may be considered comparable. When reviewing the data it should be taken into account that the comparison is between semiquantitative Level A data (field GC) and quantitative Level C data (fixed-base laboratory).

On the basis of the above information it can be concluded that the field screening effort has successfully met the objectives stated in the FSP. These were to 1) provide real-time information for determining which Optional Phase borings and monitoring wells to implement; and 2) determine which samples were to be sent for fixed-base laboratory analyses.

3.3.2 Subsurface Drilling and Soil Sampling

A total of 22 soil borings (SB-15 through SB-35 and MW-11) were drilled to characterize environmental conditions at the POL Storage Area, and to define the areal extent of contamination. The locations of the soil borings are shown in Figure 3-1. The locations of the soil borings were cleared by Base personnel prior to initiation of intrusive activities and were surveyed on completion by a land surveyor registered in the State of Texas. Drilling operations were performed by Custom Coring Inc., of Houston, Texas and supervised by a Halliburton NUS geologist.

Boreholes for all soil borings were advanced using the hollow stem auger drilling method. No fluids were used to advance the soil borings. Soil samples were collected using 2-foot long split spoon samplers containing four 6-inch long brass liners. Soil samples were continuously collected from ground surface to the top of the water table in 2.5-inch diameter by 6-inch long brass liners. Subsurface soil samples were collected within the decontaminated brass liners in order to minimize the potential loss of volatiles when the split spoon sample was opened. The brass liner at the end of the split spoon (i.e., the one closest to the shoe) was submitted for fixed based laboratory analysis because this sample had the least exposure to the atmosphere and the sampling tool. Collected samples were submitted directly

to the laboratory in these brass liners by covering the ends with Teflon tape and capping them with plastic end caps, thus further decreasing the likelihood of escape of volatiles which could occur if the soil core was removed from the unlined split spoon sampler and placed in glass sample containers. The brass liners were shipped to the laboratory where the sample was extruded and analyzed. Samples from the liners not used for laboratory analyses were described in the field by a Halliburton NUS geologist using the Unified Soil Classification System and Munsell Color Chart. Soil boring logs are in Appendix B.

Soil samples obtained from the borehole were monitored with a PID and a FID. Plastic end caps, minus the Teflon tape, were placed on the liner to be screened. A clean spike was then driven through the plastic end cap into the soil sample contained within the brass liner. The spike was quickly removed and the probe of the PID/FID was inserted into the opening. After waiting 5 seconds for the reading to stabilize, the value was recorded.

Split spoon samples were collected from the ground surface to the water table. A minimum of two and a maximum of three soil samples were collected for laboratory analysis from each boring. One sample was collected at the initial penetration depth (i.e., the first sample of native soil) and one sample was collected at the interface of the saturated and unsaturated zones. An intermediate depth sample was collected if field evidence of contamination existed. Field evidence of contamination consisted of PID/FID readings and/or visual or olfactory indicators.

Pertinent field data were recorded using soil sample log sheets and field log books. The soil sample logs sheets are contained in Appendix C and field log books are stored in the project files at the Houston, Texas office of Halliburton NUS.

Prior to start of drilling operations the drilling rig was decontaminated according to the specifications in Section 3.3.5 of this report. Soil sample collection equipment was decontaminated between sample collection events as described in Section 3.3.5.

Borings not completed as monitoring wells were backfilled with a cement/bentonite grout to ground surface using the tremie method. The tremie method is a method used for uniformly transporting materials (i.e., grout) from the grout pump via PVC piping into the bottom of the borehole.

3.3.3 Monitoring Well Installation and Development

Five conventional monitoring wells were installed to confirm the downgradient limits of the plume. The locations of the monitoring wells are depicted on Figure 3-1. Four soil borings, SB-30, SB-32, SB-33, and SB-35, drilled beyond the leading edge of the plume were converted to monitoring wells. These four locations were converted after completion of field laboratory analyses of the soil and groundwater samples. In addition, MW-11 was installed directly downgradient of MW-10 and the active fuel stand. Groundwater analyses performed on MW-10 during the SI detected low concentrations of organic compounds. Also, this location provided a confirmational sampling point at the facility property line.

The monitoring wells were constructed of 2-inch ID polyvinyl chloride (PVC) flush-joint riser pipe and flush-joint factory slotted 0.010-inch well screen. Each section of casing and screen used was National Sanitation Foundation (NSF)-approved. The 2-inch monitoring wells were installed through the hollow stem augers. Monitoring well construction and installation were supervised by a Halliburton NUS geologist. The drillers were licensed by the State of Texas. Well installation and construction conform with applicable TNRCC regulations. Well construction diagrams are located in Appendix B. Table 3-5 presents monitoring well data.

All monitoring wells were screened across the first zone of saturated soil. Semi-confined conditions existed at the site and the observed static water level was several feet above the top of the screen, as depicted in Figure 4-2. Screen lengths were 10 feet in all wells. A sediment sump was added to the base of all monitoring wells installed. After the borings were drilled to the desired depth, the well was installed through the augers. A 20/40 silica sand pack was installed using the augers as a tremie into the boring annulus around the well screen. The sand pack was installed from the bottom of the hole to approximately 2 feet above the top of the well screen. A 100 percent sodium bentonite pellet seal was installed above the sand pack and allowed to hydrate a minimum of one hour. The depths of all backfill materials were constantly monitored during the well installation process by means of a weighted plastic tape.

A 4-inch diameter protective stainless steel above grade casing equipped with a locking steel cap was installed around monitoring well MW-11. In addition, a concrete apron measuring 4 feet by 4 feet by 4 inches was constructed equally

TABLE 3-5

MONITORING WELL DATA
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Monitor Well	Texas State Plane Coordinate System		Top of Casing Elevation[b]	Natural Ground Elevation	Depth Below Top of Casing	Depth Below Grade	Screened Interval Below Grade	Filter Pack Below Grade	Bottom of Well Elevation
	North Coordinate[a]	East Coordinate							
MW-11	659,049.99	3,218,214.73	28.31	25.84	31.65	29.5	16.9-25.9	14.5-29.5	-3.34
MW-12	659,015.64	3,218,335.30	23.14	23.19	27.18	27.9	15.2-24.5	12.0-27.9	-4.04
MW-13	658,914.99	3,218,350.44	23.11	23.47	27.64	28.1	15.5-24.5	12.5-28.1	-4.53
MW-14	659,053.59	3,218,288.39	23.99	24.10	27.70	28.2	15.5-24.5	12.5-28.2	-3.71
MW-15	659,057.18	3,218,346.67	23.45	23.90	28.0	28.0	15.4-24.4	12.0-28.0	-4.55

(a) Coordinates are referenced to Texas Coordinate System, South Central Zone, and are based on U.S.L. & G.S. Survey Marker 1952.

(b) All elevations in feet with respect to 1929 NGVD Datum, 1987 adjustment

portioned around the casing of the well. At the request of Base personnel, marker posts were not installed around the well base.

Four monitoring wells, MW-12 through MW-15, were completed as flush-mounted wells. The wells have a locking water-tight cap. An 8-inch diameter manhole was set in a 2-foot by 2-foot by 4-inch concrete apron around the well. All locks supplied for the wells were keyed alike. The keys for these wells were delivered to POL Storage Area personnel.

The monitoring wells were developed no sooner than 24 hours after well completion. Wells were developed by surging and pumping. Monitoring wells were developed until water was essentially sediment free. The pH, temperature, turbidity, and specific conductivity of the development water was periodically measured and recorded on monitoring well development forms. Monitoring well development forms are in Appendix D.

3.3.4 Groundwater Sampling

Groundwater samples were obtained from the nine groundwater monitoring wells installed at the POL Storage Area. Four of the monitoring wells were previously installed during the SI. Upon removal of the casing cap, the air in the breathing zone was checked with a FID meter. Prior to obtaining samples, water levels were measured and the wells purged using a submersible pump. Field measurements of pH, temperature, specific conductance, and turbidity were taken after removal of each borehole volume purged. Monitoring wells were purged until field parameters reach a state of equilibrium. A minimum of three borehole volumes were purged.

A new disposable teflon bailer was used for the collection of each groundwater sample. The bailers were secured with dedicated polyethylene rope bailing line and utilized a Teflon-coated stainless steel leader with sufficient length to prevent submergence of the uncoated polyethylene rope. Immediately after sampling, the temperature, pH, turbidity, and conductivity of the water sample were measured and recorded on the groundwater sample log sheets. The sample was poured directly from the bailer into the appropriate sample bottles for analysis. Samples to be analyzed for volatile constituents were collected first and immediately sealed in containers so that no head space existed. Pertinent field and sampling data were recorded using a groundwater log sheets and the field log book. The groundwater sample log sheets are contained in Appendix C, and field log books are stored within the project files at the Houston, Texas office of Halliburton NUS.

Groundwater samples were also collected from each borehole using a decontaminated stainless steel bailer. These borehole groundwater samples were analyzed using the field GC. The augers were advanced into the saturated sediments, drilling was halted and groundwater was allowed to enter the hollow stem augers. Three annular volumes were then purged using a submersible pump. The groundwater water sample was collected using a decontaminated stainless steel bailer and transferred to a 40-ml volatile organic analysis (VOA) vial.

3.3.5 Decontamination Procedures

The equipment involved in field sampling activities was decontaminated prior to and during drilling and sampling activities. This equipment included the drilling rig, downhole tools, augers, well casing and screens, and soil and groundwater sampling equipment.

Major Equipment

All drilling equipment, including downhole drilling and sampling tools and portions of the drilling rig that stood above the borehole, were cleaned with high-pressure water and Alconox (or equivalent) and rinsed with potable water prior to beginning work, between boreholes, and at the conclusion of the drilling program.

Well casing and screens were cleaned with high-pressure water prior to being installed into the borings. Decontamination of major equipment took place within the concrete diked area at the POL Storage Area, as designated by base personnel.

Soil Sampling Equipment

All sampling equipment used for collecting soil samples was decontaminated both prior to beginning field sampling and between samples. The following decontamination steps were taken:

- Alconox or liquinox detergent wash
- Potable water rinse
- Pesticide-grade methanol rinse
- Reagent grade water rinse

- Air dry
- Wrap in aluminum foil (if not used immediately)

Sampling equipment was decontaminated in tubs or drainage pans so that rinsate solvents could be collected and disposed of properly.

Groundwater Sampling Equipment

Submersible pumps were cleaned in the following manner:

- Wash with Alconox and potable water
- Rinse with potable water
- Rinse with analyte free water

Groundwater sampling equipment was decontaminated or disposed of after each usage. Polypropylene or polyethylene ropes and teflon bailers were dedicated for each sampling event and discarded after each use. All other non-disposable water sampling equipment was decontaminated in the following manner:

- Wash with Alconox (or equivalent) and potable water
- Rinse with potable water
- Rinse with pesticide grade methanol
- Rinse with reagent grade water
- Air dry
- Wrap in aluminum foil (if not used immediately)

Field analytical equipment such as turbidity, pH, conductivity and water level probes were rinsed with reagent-grade water.

3.3.6 Sample Handling

Soil samples were collected in brass liners as previously described, thus eliminating the need for soil sample containers. However, groundwater samples were placed in laboratory-supplied containers. After placement into appropriate sample containers, the samples were sealed and appropriately marked sample labels were attached to the sample containers in order to uniquely identify the samples. The marked samples were then sealed in zip-lock bags and placed in coolers containing ice. A chain of custody form was filled out for the samples and

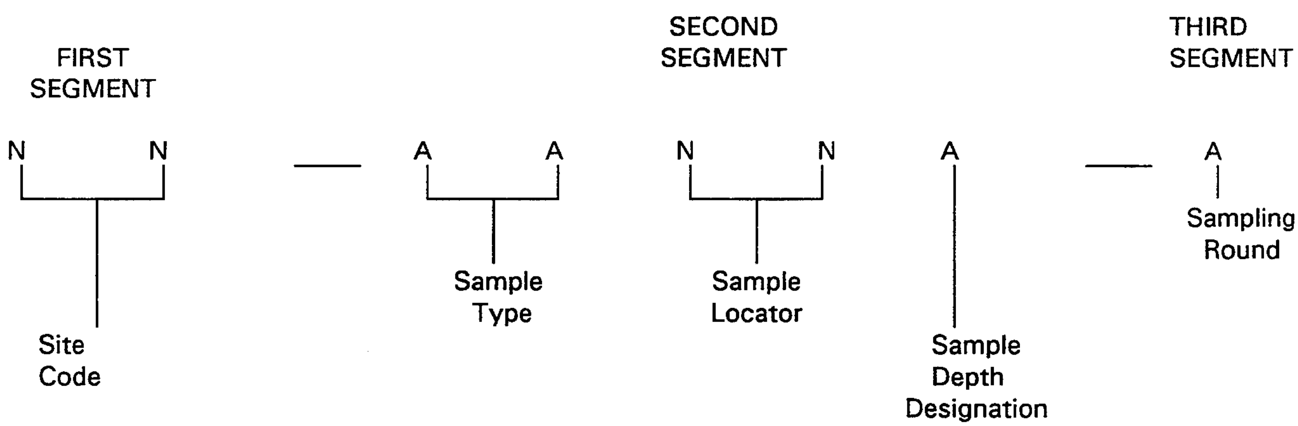
the samples were hand-delivered to PACE Laboratories in Houston, Texas. The chain of custody forms pertaining to the SC are contained in Appendix E.

3.3.7 Sample Identification System

A sample identification system was used in the field to identify each sample taken during the sampling program. This coding system provides a tracking record to allow retrieval of information about a particular sample and assure that each sample was uniquely identified.

Each sample was assigned a unique alphanumeric number that identified the installation, the site, the specific sample location, and the matrix sampled. These numbers were used to track the sample from collection, through analysis, and into the final report.

The alphanumeric coding employed for sample numbering is presented in the following diagram and definitions:



Character Type:

A = Alpha
N = Numeric

Site Code: POL Storage Area -02

Sample Type: These include, the following:

MW	=	Groundwater from Monitoring Well
SB	=	Subsurface Soil from Soil Boring
FB	=	Field Blank
TB	=	Trip Blank
RB	=	Rinsate Blank
FD	=	Field Duplicate

Sample Locator:

Sample locators indicated precisely where each sample was collected. In the case of blanks, this number was assigned in the order collected.

Sample Depth Designation:

This designation allowed for the distinction of samples collected from different depths at the same location. For example, if soil samples were collected from the same boring at 0-2, 4-6, and 8-10 feet below grade, they would be designated A, B, and C, from top to bottom. Depth designations were assigned and recorded in the field.

Sampling Round:

Sampling rounds were in alphabetical sequence beginning with "A".

Example:

02-SB07B-A

This code would identify the second subsurface soil sample collected from soil boring 07 at the POL Storage Area during the first sampling round.

3.3.8 Waste Management

The decontamination of major equipment (i.e., drill rig and associated equipment) was done at a location within the concrete diked designated

by Ellington Field Air National Guard Base personnel, where the water generated was discharged to an oil/water separator.

Drill cuttings were containerized in Department of Transportation (DOT)-approved 55-gallon drums. Based on the results of the analyses, a determination will be made by ANGRC whether off-site disposal and/or treatment is required. Development and purge water from monitoring wells was also drummed pending results of laboratory analyses.

3.3.9 Aquifer Testing

In-situ permeability testing was performed on all monitoring wells installed and developed by Halliburton NUS during the SC to provide data on the hydraulic characteristics of the tested aquifer. The monitoring wells installed during the SI were previously tested during the SI. These tests included a falling head (slug-in) and a rising head (slug-out) test. The tests were performed using a Model SE 1000C Hermit Environmental Data Logger. The slug consisted of a solid PVC cylinder attached to a dedicated rope. The following procedure was employed:

- The data logger pressure transducer probe was lowered into the well.

- The static water level in the monitoring well was measured to the nearest 0.01 foot using an electric water level meter with an audible alarm. This value was input into the data logger and used as the zero (equilibrium) point. The data logger was then calibrated in accordance with the specific parameters and required data output.

- The slug-in test commenced as the solid PVC slug of known volume was rapidly lowered into the well until the slug was fully submerged. The recording unit was activated simultaneously with the submersion of the slug.

- The change in height of the water column was recorded at logarithmic time intervals until the well reached equilibrium (i.e., in excess of 90 percent recovery).

- The data logger was then recalibrated for the slug-out test.

- The slug-out test commenced with the rapid removal of the PVC slug and the simultaneous activation of the recording unit.

- The change in height of the water column was recorded at logarithmic time intervals until the well reached equilibrium (i.e., in excess of 90 percent recovery).

3.3.10 Surveying

The five recently installed groundwater wells were surveyed following installation along with the sixteen soil borings in which wells were not installed. All surveyed locations were measured by a surveyor registered in the State of Texas. The locations are tied into the Texas State Plane Coordinate System. The surveys are of third order accuracy (cf. Urquhart, L.C., 1962 Civil Engineering Handbook, 4th Edition, p. 96 and p. 97). Horizontal locations and ground surface elevations were measured to an accuracy of 0.1 feet. A notch was made in the PVC casing at each well to provide a consistent measurement point for subsequent groundwater elevation measurements. Figure 3-1 provides project survey data.

4.0 RESULTS OF INVESTIGATION

4.1 Site Geology and Hydrogeology

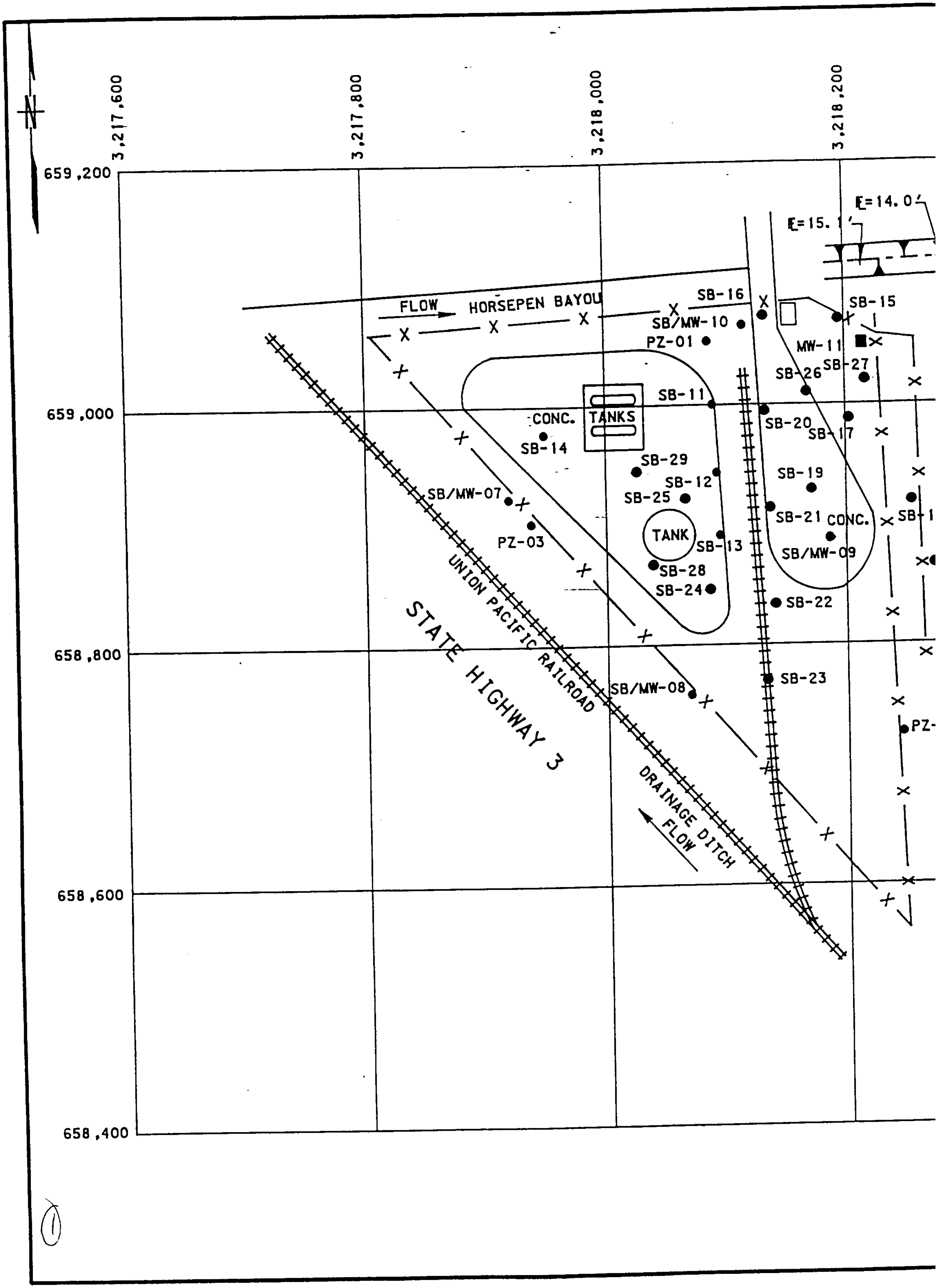
4.1.1 Site Geology

The geological setting of the POL Storage Area was determined through the drilling of 22 soil borings and a review of previous SI activities. The locations of these borings are shown in Figure 4-1. Boring log data in Appendix B provide a detailed description of the lithologies encountered.

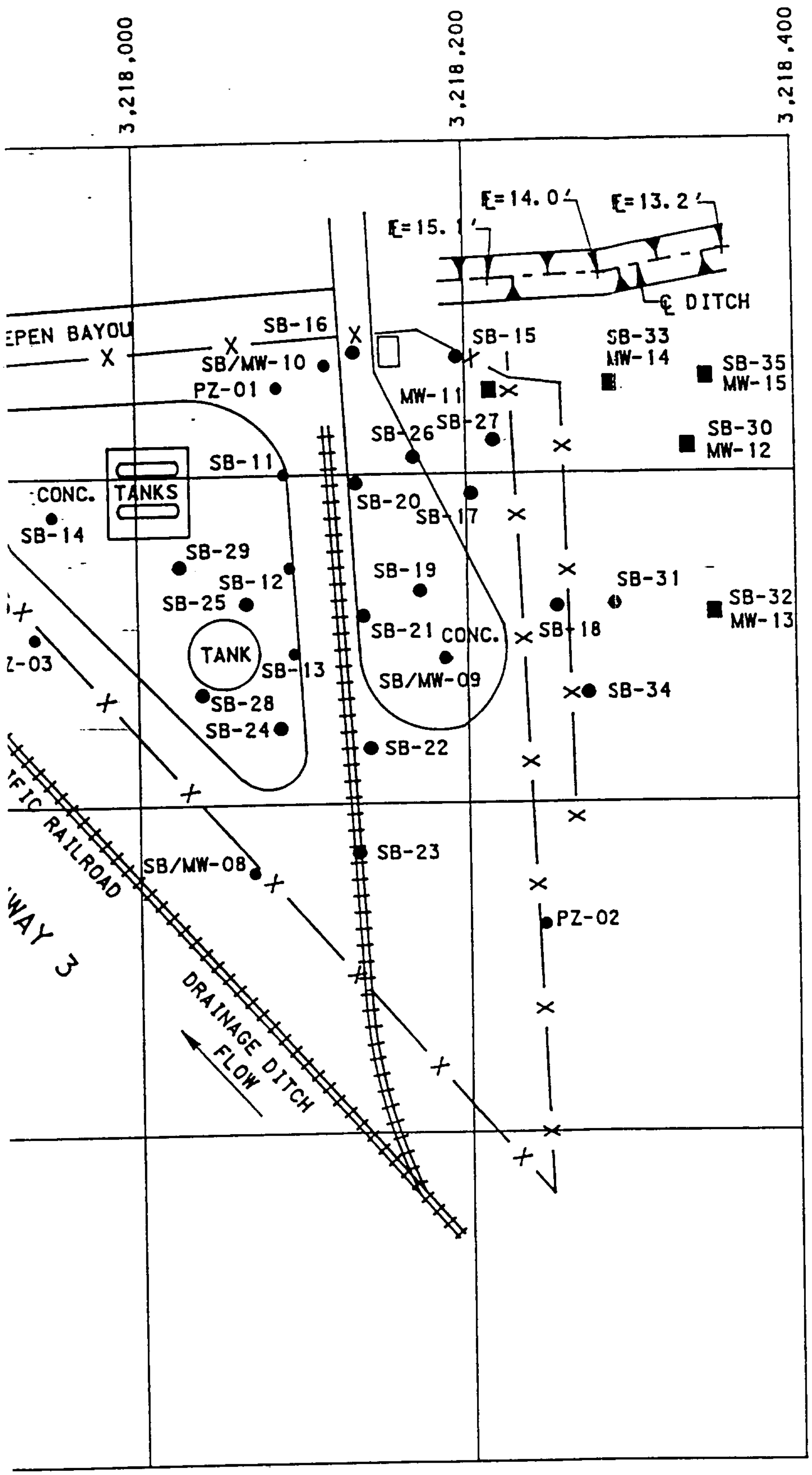
The borings at the POL Storage Area drilled during the SC ranged in depth from 18 to 30 feet below grade. The following is a description of the stratigraphy beneath the site including the Unified Soil Classification System codes (e.g. CH). Description of the units are similar to the descriptions presented in the SI report.

> Zone 1A - The upper portion of the geologic section encountered in the soil borings consists of a dark brown to black to gray, medium stiff, plastic clay (CH). Minor amounts of silt and sand are contained in the zone, mainly in the lower portions. Iron staining is present, as are calcareous zones. The upper few feet of section encountered in most borings consists of a dark gray to black to brown hard clay (OL) with a variable organic content. The thickness of Zone 1A varies from a minimum of 6 feet in Soil Borings SB-18 and SB-32 (located in the eastern portion of the site) to a maximum of 17 feet in Soil Boring SB-25 (located in the central portion of the site). The average thickness of Zone 1A in the 22 borings completed by Halliburton NUS during the SC is approximately 10 feet.

> Zone 1B - Zone 1B is a gray to brown, medium stiff to stiff, silty clay (CL). The interface between Zones 1A and 1B is gradational. The silt content generally increases with depth, as does the brown coloring. Iron staining is common, as are iron nodules. This unit grades downward into the first zone of saturated sediments. The thickness of Zone 1B varies from 0 (i.e., absent) in Soil Boring SB-25 (located in the central portion of the site) to a maximum of 12 feet in Soil Borings SB-16 and MW-11 (located in the northeastern portion of the site).



3,217,600
3,217,800
3,218,000
3,218,200
659,200
659,000
658,800
658,600
658,400
E=15.1'
E=14.0'
FLOW
HORSEPEN BAYOU
SB-16
SB-15
SB/MW-10
PZ-01
MW-11
SB-26
SB-27
SB-11
CONC.
TANKS
SB-20
SB-17
SB-14
SB-29
SB-12
SB-19
SB/MW-07
SB-25
SB-21
CONC.
TANK
SB-13
SB/MW-09
PZ-03
SB-28
SB-24
SB-22
STATE HIGHWAY 3
UNION PACIFIC RAILROAD
SB/MW-08
SB-23
DRAINAGE DITCH
FLOW



POINT NUMBER	TEXAS PLANE COORDINATES SOUTH CENTRAL ZONE	
	NORTHING	EASTING
MW-11	659,049.99	3,218,21
SB-15	659,070.46	3,218,19
SB-16	659,076.67	3,218,13
SB-17	658,987.90	3,218,20
SB-18	658,919.21	3,218,25
SB-19	658,929.26	3,218,17
SB-20	658,994.85	3,218,13
SB-21	658,914.15	3,218,13
SB-22	658,833.89	3,218,13
SB-23	658,770.22	3,218,13
SB-24	658,846.48	3,218,08
SB-25	658,922.17	3,218,06
SB-26	659,010.33	3,218,16
SB-27	659,020.19	3,218,21
SB-28	658,867.37	3,218,03
SB-29	658,945.57	3,218,02
SB-30/MW-12	659,015.64	3,218,33
SB-31	658,920.39	3,218,29
SB-32/MW-13	658,914.99	3,218,35
SB-33/MW-14	659,053.59	3,218,28
SB-34	658,866.38	3,218,27
SB-35/MW-15	659,057.18	3,218,34

NOTES:

1. ALL ELEVATIONS SHOWN HEREON ARE M-1276 WITH ELEVATION OF 24.52 1987 ADJUSTMENT.
2. ALL COORDINATES ARE REFERENCED SOUTH CENTRAL ZONE AND ARE BASE MARKER ELLINGTON 1952 HAVING C EAST: 3,215,019.21 WITH A GRID
3. MONITOR WELLS MW-07 THROUGH MW- THROUGH SB-14 WERE INSTALLED I

LEGEND:

■ MW = MONITOR WELL
● SB = SOIL BORING
NG = NATURAL GROUND
CONC. = CONCRETE

MO

SURVEY

DRAWN

CHECKE

PAGE

POINT NUMBER	TEXAS PLANE COORDINATES SOUTH CENTRAL ZONE NORTHING	EASTING	ELEVATIONS TOP OF CASING (PVC PIPE)	TOP OF CONCRETE OR NATURAL GROUND	
MW-11	659,049.99	3,218,214.73	28.31	25.84	(NG)
SB-15	659,070.46	3,218,194.84		25.56	(NG)
SB-16	659,076.67	3,218,131.41		25.54	(CONC)
SB-17	658,987.90	3,218,202.84		25.41	(NG)
SB-18	658,919.21	3,218,254.28		23.61	(NG)
SB-19	658,929.26	3,218,170.92		25.68	(CONC)
SB-20	658,994.85	3,218,132.13		25.61	(CONC)
SB-21	658,914.15	3,218,136.01		25.79	(CONC)
SB-22	658,833.89	3,218,139.60		26.41	(NG)
SB-23	658,770.22	3,218,131.90		26.01	(NG)
SB-24	658,846.48	3,218,085.31		24.25	(CONC)
SB-25	658,922.17	3,218,065.48		23.83	(CONC)
SB-26	659,010.33	3,218,167.85		26.06	(NG)
SB-27	659,020.19	3,218,216.74		25.86	(NG)
SB-28	658,867.37	3,218,038.28		23.98	(CONC)
SB-29	658,945.57	3,218,025.47		23.66	(CONC)
SB-30/MW-12	659,015.64	3,218,335.30	23.14	23.19	(NG)
SB-31	658,920.39	3,218,290.10		23.31	(NG)
SB-32/MW-13	658,914.99	3,218,350.44	23.11	23.47	(NG)
SB-33/MW-14	659,053.59	3,218,288.39	23.99	24.10	(NG)
SB-34	658,866.38	3,218,272.98		23.51	(NG)
SB-35/MW-15	659,057.18	3,218,346.67	23.45	23.90	(NG)

NOTES:

1. ALL ELEVATIONS SHOWN HEREON ARE BASED ON NGS BENCHMARK M-1276 WITH ELEVATION OF 24.52 FEET, NGVD 1929 DATUM, 1987 ADJUSTMENT.
2. ALL COORDINATES ARE REFERENCED TO THE TEXAS COORDINATE SYSTEM, SOUTH CENTRAL ZONE AND ARE BASED ON U.S.C. & G.S. SURVEY MARKER ELLINGTON 1952 HAVING COORDINATES OF NORTH: 662,268.83, EAST: 3,215,019.21 WITH A GRID FACTOR OF 0.9998723.
3. MONITOR WELLS MW-07 THROUGH MW-10 AND SOIL BORINGS SB-11 THROUGH SB-14 WERE INSTALLED IN JANUARY 1990 DURING THE SI.

FIGURE 4-1

LEGEND:

- ■ MW = MONITOR WELL
- ● SB = SOIL BORING
- NG = NATURAL GROUND
- CONC. = CONCRETE

HALLIBURTON NUS Environmental Corporation

MAP SHOWING LOCATIONS AND ELEVATIONS OF MONITORING WELLS & SOIL BORINGS AT THE POL STORAGE AREA ELLINGTON FIELD (ANG.) HOUSTON, TEXAS

SURVEYED BY: JDC	SCALE: 1" = 100'
DRAWN BY: D. GROSSHANDLER	DATE: 09-10-93
CHECKED BY: L. BASILIO	JOB NO.: NQ-1K94-BB

HOU07US - /USR19A/HCIVIL/910333/NQ1K94BB.DGN-02

The average thickness of Zone 1B in the 22 borings completed by Halliburton NUS is approximately 8 feet.

Zone 2 - Zone 2 is the first unit encountered which contains saturated sediments. The unit consists of deposits of brown silt (ML) and sand (SM) with variable quantities of admixed silt and clay. Iron staining is present in this unit. The sand contained within this unit is generally very fine- to fine-grained, well sorted, and is unconsolidated. The sands and silts are slightly clayey in some of the borings. Soil Boring SB-33 encountered silty clay layers within Zone 2. Occasional pebbles are also encountered in Zone 2. All soil borings installed during the SC were terminated within this zone. The average thickness of Zone 2, based upon information from the SI, is approximately 13.5 feet.

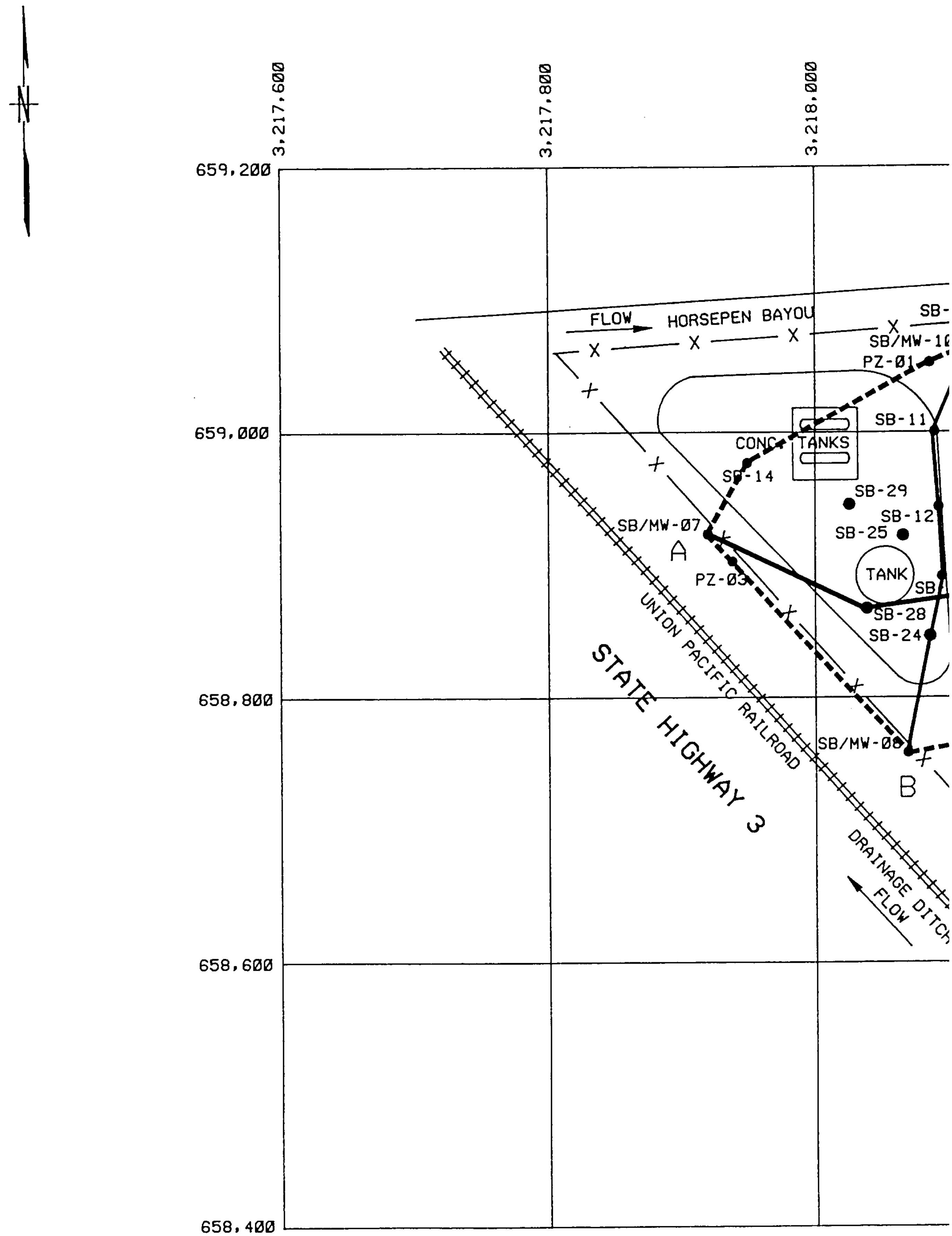
Zone 3 - Zone 3 is a brown sandy and silty clay (CL). The clay is very stiff to hard, and contains some sandy seams. None of the borings drilled at the site during the SC encountered this zone. Three soil borings drilled during the SI encountered this zone.

Two cross-sections and one fence diagram were constructed using the available boring log data. Figure 4-2 depicts the cross-sectional lines. Figures 4-3 through 4-5 contain the cross-sections and a fence diagram.

4.1.2 Site Hydrogeology

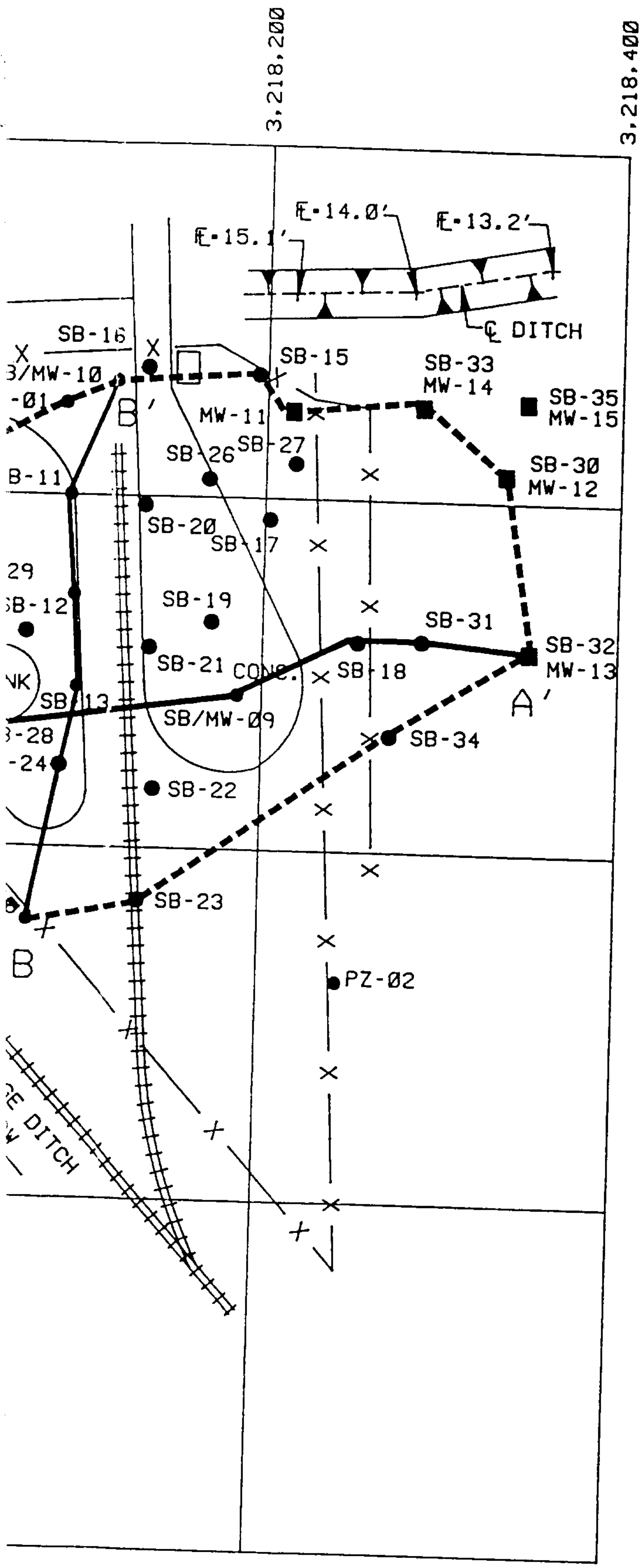
Five monitoring wells (MW-11 through MW-15) were installed at the site as part of the SC. Table 3-3 depicts pertinent monitoring well data for these five wells. Four monitoring wells (MW-07 through MW-10) were previously installed as part of the SI. All the wells are screened across the first zone of saturated sediments (i.e., Zone 2).

The collection of groundwater elevation data has made it possible to determine groundwater flow direction and hydraulic gradient beneath the site. Figure 4-6 is a groundwater contour map depicting flow across the site. The map depicts groundwater flow direction as easterly, with a slight bending to the east southeast in the southern portion of the POL Storage Area. The hydraulic gradient estimated from the groundwater contours in Figure 4-6 is 0.0027 feet/feet (14.26 feet/mile).



N
3,217,600
3,217,800
3,218,000
659,200
659,000
658,800
658,600
658,400
FLOW
HORSEPEN BAYOU
SB/MW-10
PZ-01
SB-11
CONC.
TANKS
SB-14
SB-29
SB-12
SB-25
SB/MW-07
A
TANK
PZ-03
SB-28
SB-24
UNION PACIFIC RAILROAD
STATE HIGHWAY 3
SB/MW-08
B
DRAINAGE DITCH
FLOW

1



A-A' - CROSS SECTION

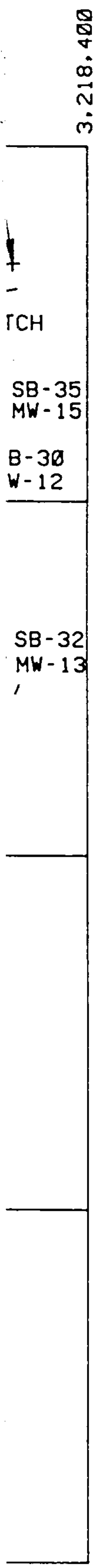
- - - - - - FENCE DIAGRAM

FIGURE 4-2

HALLIBURTON NUS
Environmental Corporation

CROSS SECTION LINES
POL STORAGE AREA
ELLINGTON FIELD (ANG.)
HOUSTON, TEXAS

SURVEYED BY:	JDC	SCALE:	1" = 100'
DRAWN BY:	D. GROSSHANDLER	DATE:	10-20-93
CHECKED BY:	L. BASILIO	JOB NO.:	NQ-1K94-BE



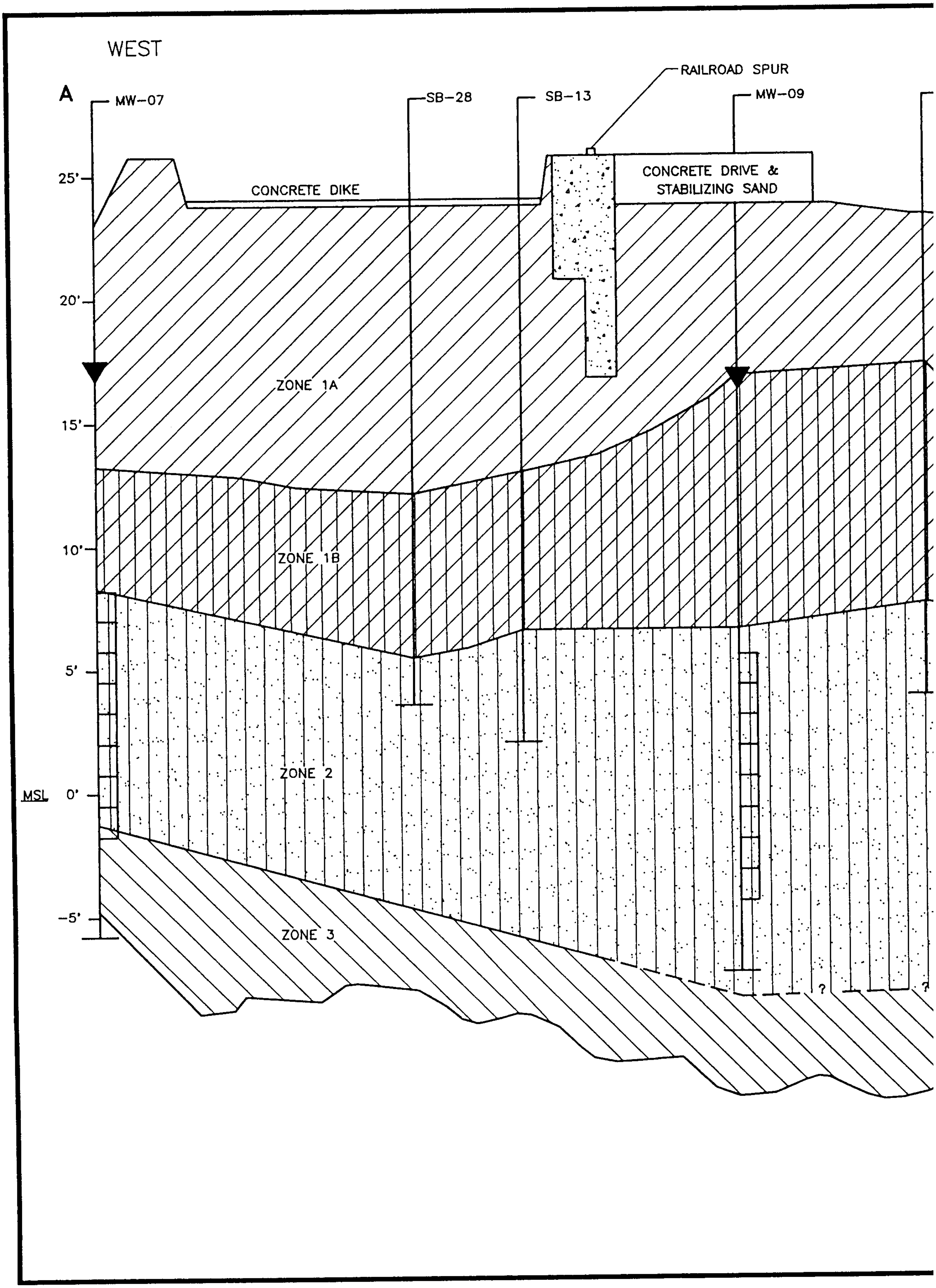
A-A' - CROSS SECTION
----- - FENCE DIAGRAM

FIGURE 4-2

HALLIBURTON NUS
Environmental Corporation

CROSS SECTION LINES
POL STORAGE AREA
ELLINGTON FIELD (ANG.)
HOUSTON, TEXAS

SURVEYED BY: JDC	SCALE: 1" - 100'
DRAWN BY: D. GROSSHANDLER	DATE: 10-20-93
CHECKED BY: L. BASILIO	JOB NO.: NQ-1K94-BB



WEST
A
MW-07
SB-28
SB-13
RAILROAD SPUR
MW-09
CONCRETE DIKE
CONCRETE DRIVE &
STABILIZING SAND
25'
20'
15'
10'
5'
MSL
0'
-5'
ZONE 1A
ZONE 1B
ZONE 2
ZONE 3
?
?

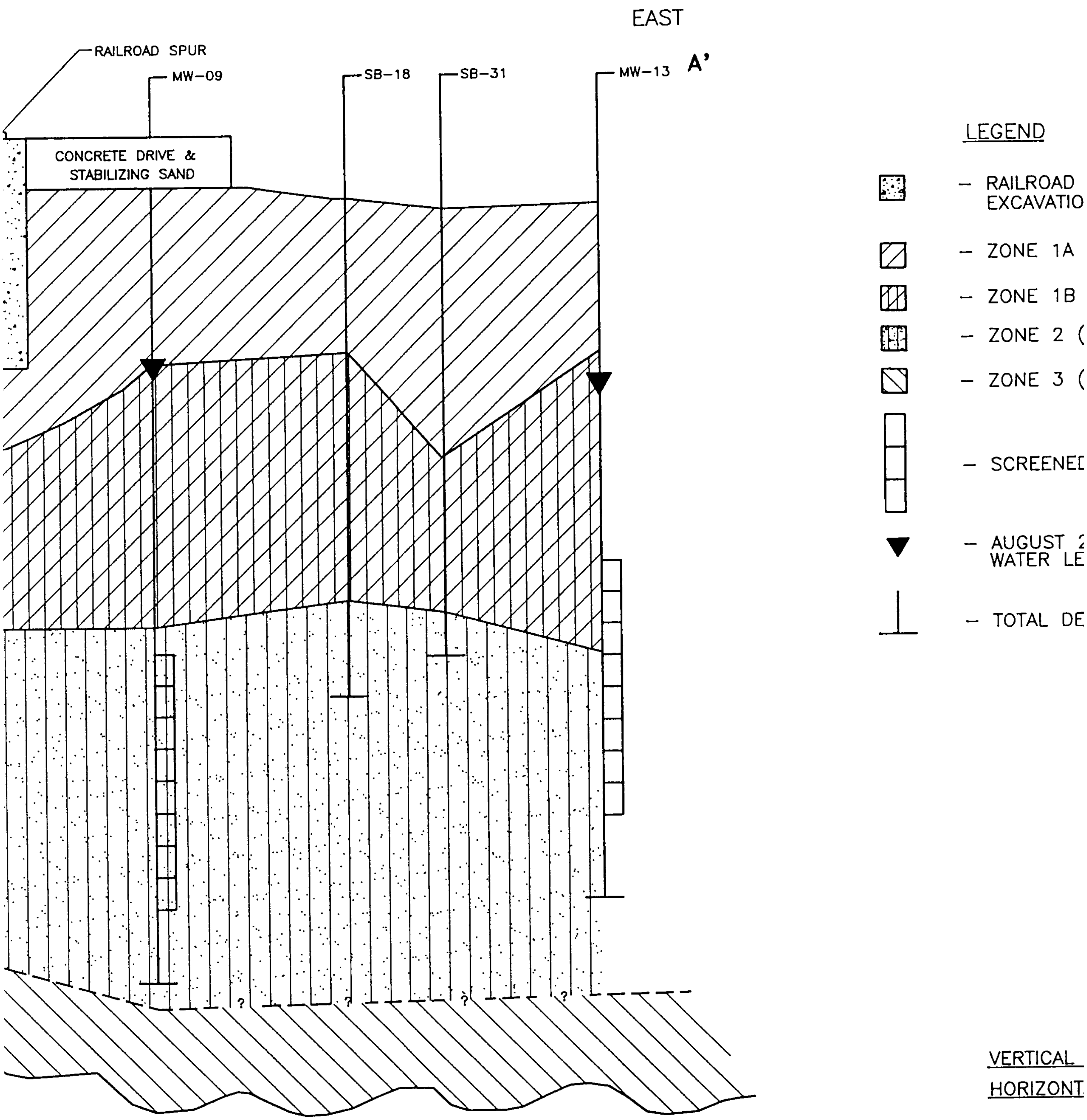


FIGURE 4-3

DRAWN BY	D. GROSSHANDLER	CROSS-SECTION A-A' POL STORAGE AREA ELLINGTON FIELD (ANG) HOUSTON,
DATE:	12/1/93	
GEOLOGIST:	L. BASILO	
DATE:	12/1/93	
CAD DWG. NO.	L-3.DWG	SCALE: AS NOTED · BRE. DWG. NO.: 1K94-DA

LEGEND

– RAILROAD BALLAST AND EXCAVATION BACKFILL

– ZONE 1A (CLAY)

– ZONE 1B (SILTY CLAY)

– ZONE 2 (CLAYEY SILT AND SILTY SAND)

– ZONE 3 (SILTY CLAY)

– SCREENED INTERVAL

– AUGUST 27, 1993 WATER LEVEL

– TOTAL DEPTH OF BORING

VERTICAL SCALE: 1" = 5'

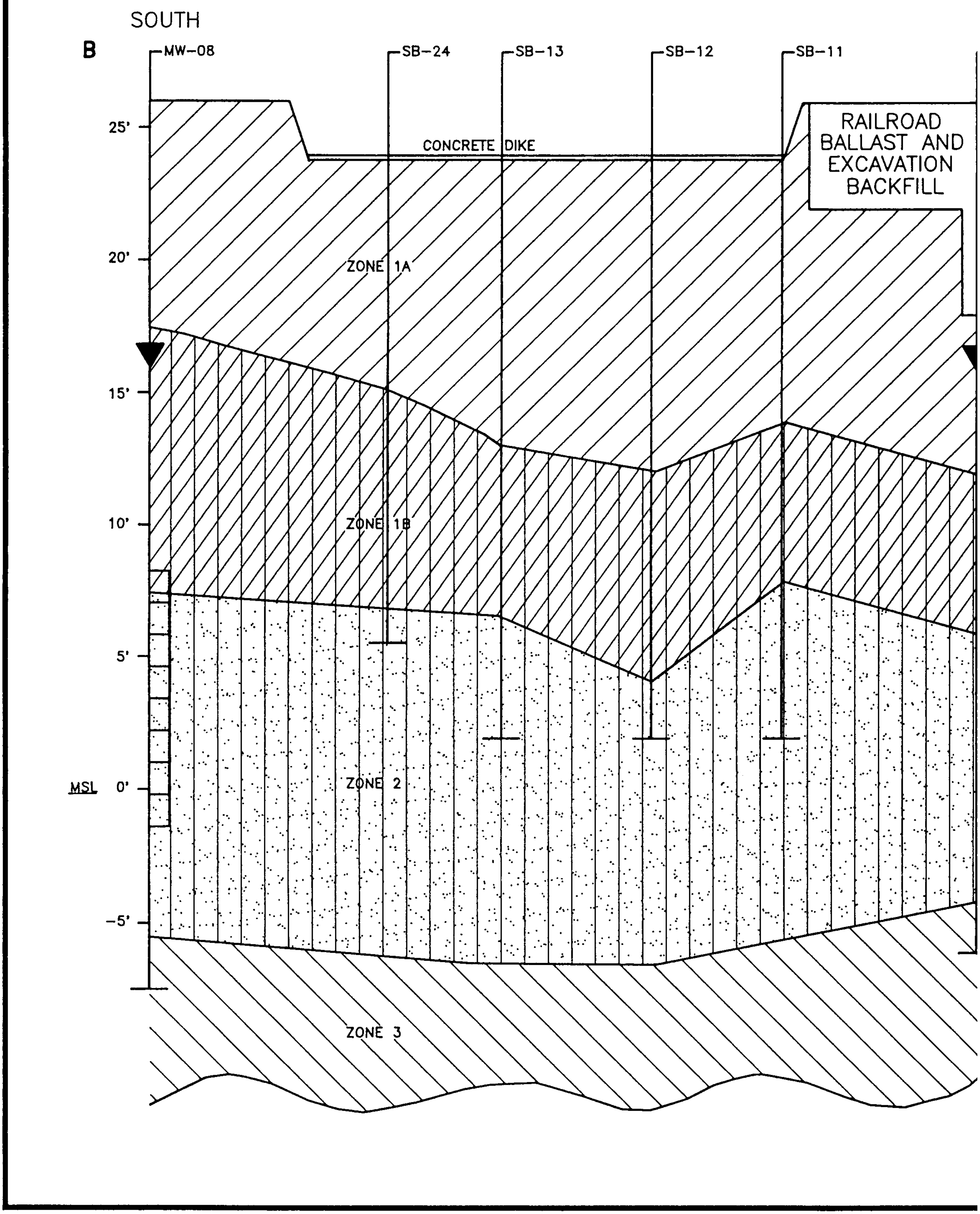
HORIZONTAL SCALE : 1" = 50'

FIGURE 4-3

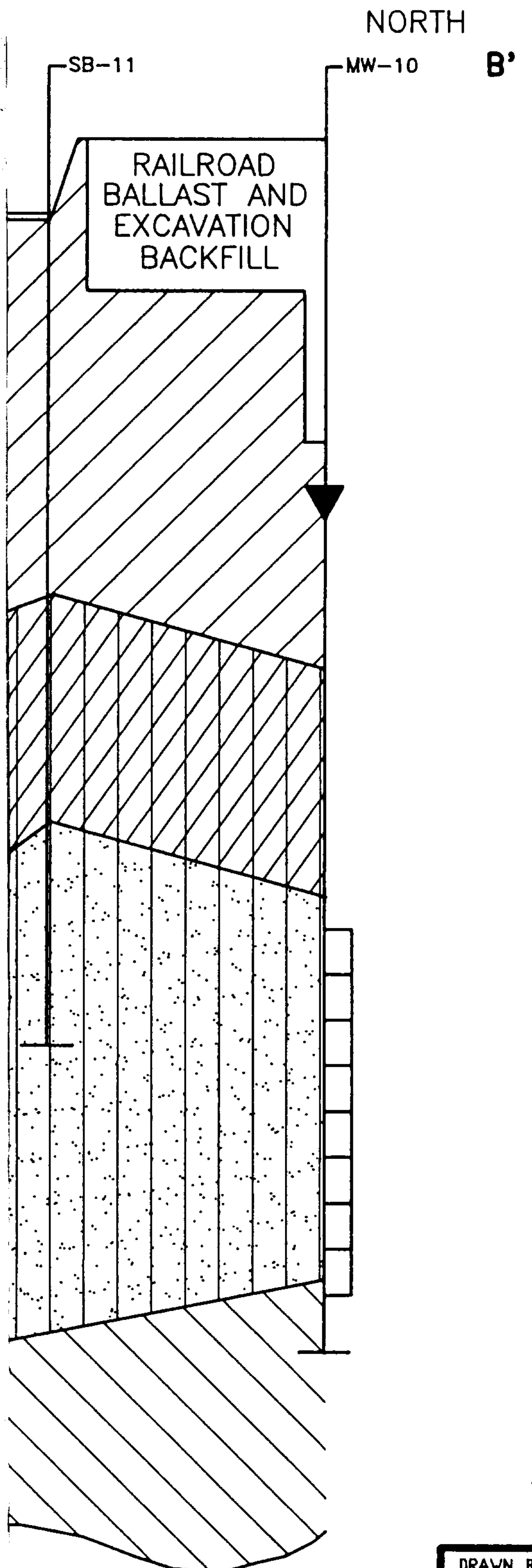
CROSS-SECTION A-A'
POL STORAGE AREA
ELLINGTON FIELD (ANG) HOUSTON, TEXAS

SCALE: AS NOTED	BRE. DWG. NO.: 1K94-DA	REV. 0

HALLIBURTON NUS
Environmental Corporation



SOUTH
B
MW-08
SB-24
SB-13
SB-12
SB-11
25'
20'
15'
10'
5'
MSL
0'
-5'
CONCRETE DIKE
RAILROAD BALLAST AND EXCAVATION BACKFILL
ZONE 1A
ZONE 1B
ZONE 2
ZONE 3



LEGEND

- ZONE 1A (CLAY)
- ZONE 1B (SILTY CLAY)
- ZONE 2 (CLAYEY SILT AND SILTY SA
- ZONE 3 (SILTY CLAY)
- SCREENED INTERVAL
- AUGUST 27, 1993 WATER LEVEL
- TOTAL DEPTH OF BORING

VERTICAL SCALE: 1" = 5'

HORIZONTAL SCALE : 1" = 50'

FIGURE 4-4

DRAWN BY	D. GROSSHANDLER
DATE:	09/27/93
GEOLOGIST:	L. BASILO
DATE:	09/27/93
CAD DWG. NO.	L-1.DWG

CROSS-SECTION B-B'
POL STORAGE AREA
ELLINGTON FIELD (ANG) HOUSTON, TEXAS

SCALE: AS NOTED | BRE. DWG. NO.: 1K94-DA | REV. 0

HA
Env

LEGEND

- ZONE 1A (CLAY)
- ZONE 1B (SILTY CLAY)
- ZONE 2 (CLAYEY SILT AND SILTY SAND)
- ZONE 3 (SILTY CLAY)
- SCREENED INTERVAL
- AUGUST 27, 1993 WATER LEVEL
- TOTAL DEPTH OF BORING

'ERTICAL SCALE: 1" = 5'

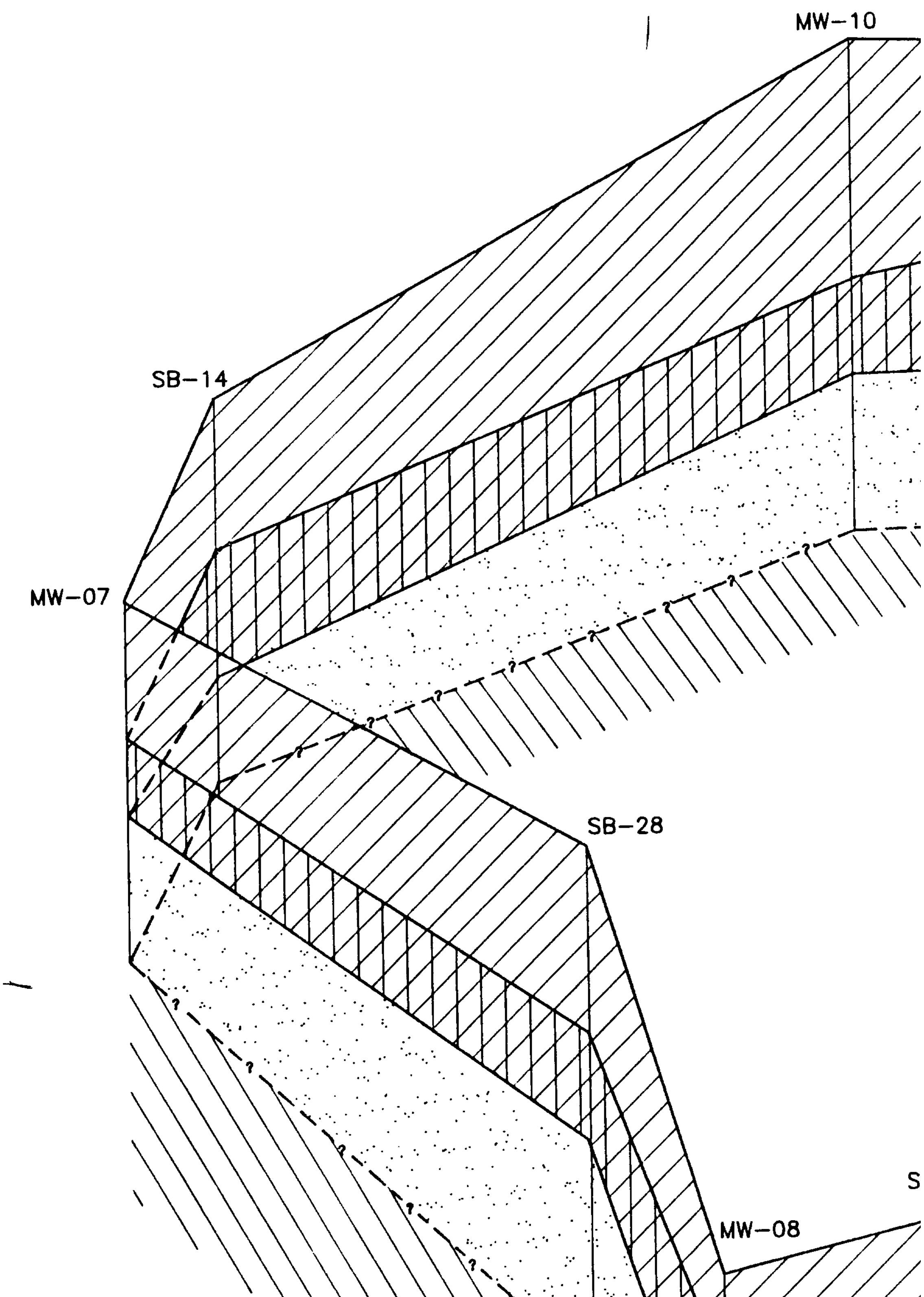
IORIZONTAL SCALE : 1" = 50'

FIGURE 4-4

CROSS-SECTION B-B'
POL STORAGE AREA
ELLINGTON FIELD (ANG) HOUSTON, TEXAS

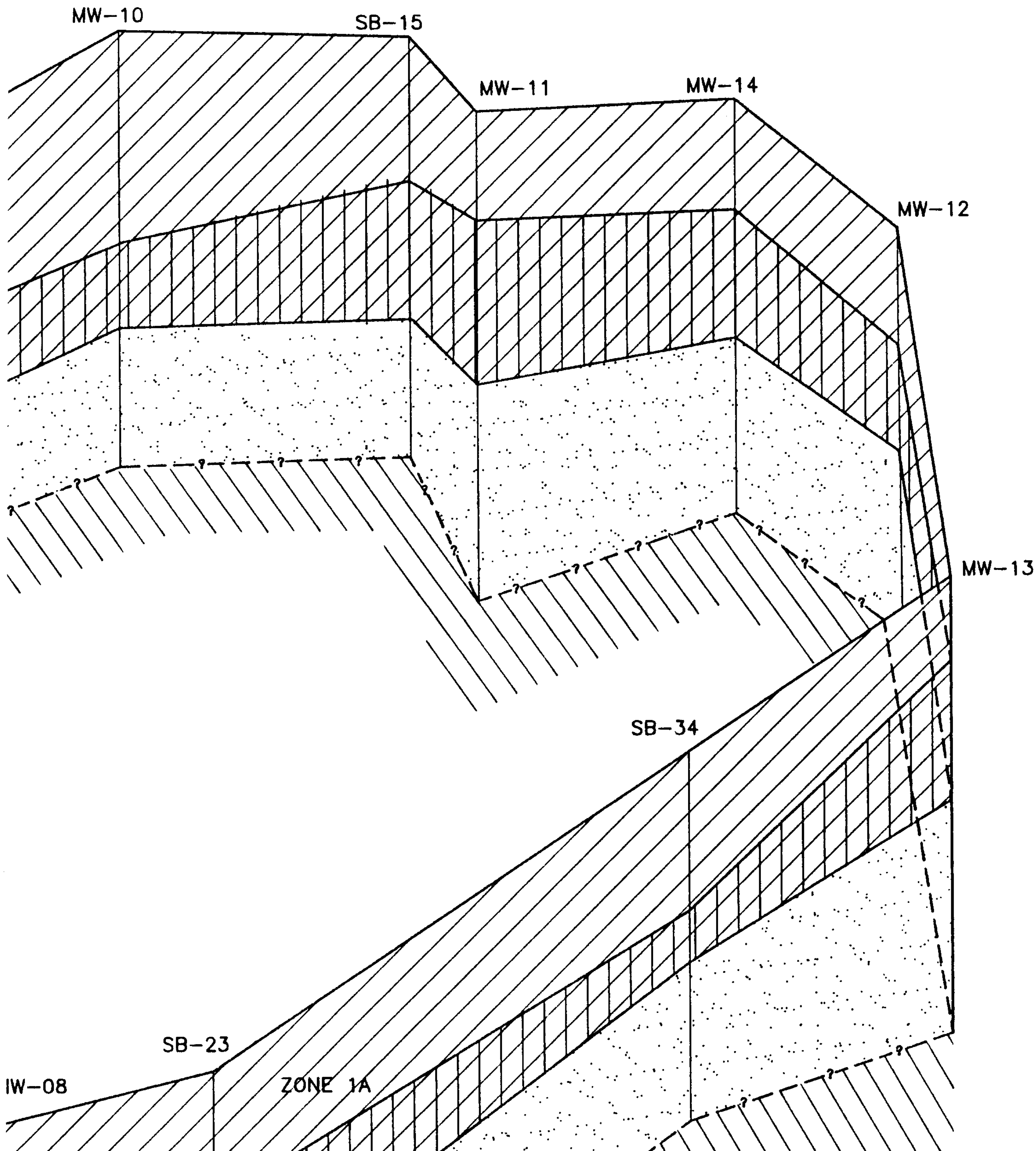
CALE: AS NOTED	BRE. DWG. NO: 1K94-DA	REV. 0

HALLIBURTON NUS
Environmental Corporation



MW-10
SB-14
MW-07
SB-28
MW-08
S

2

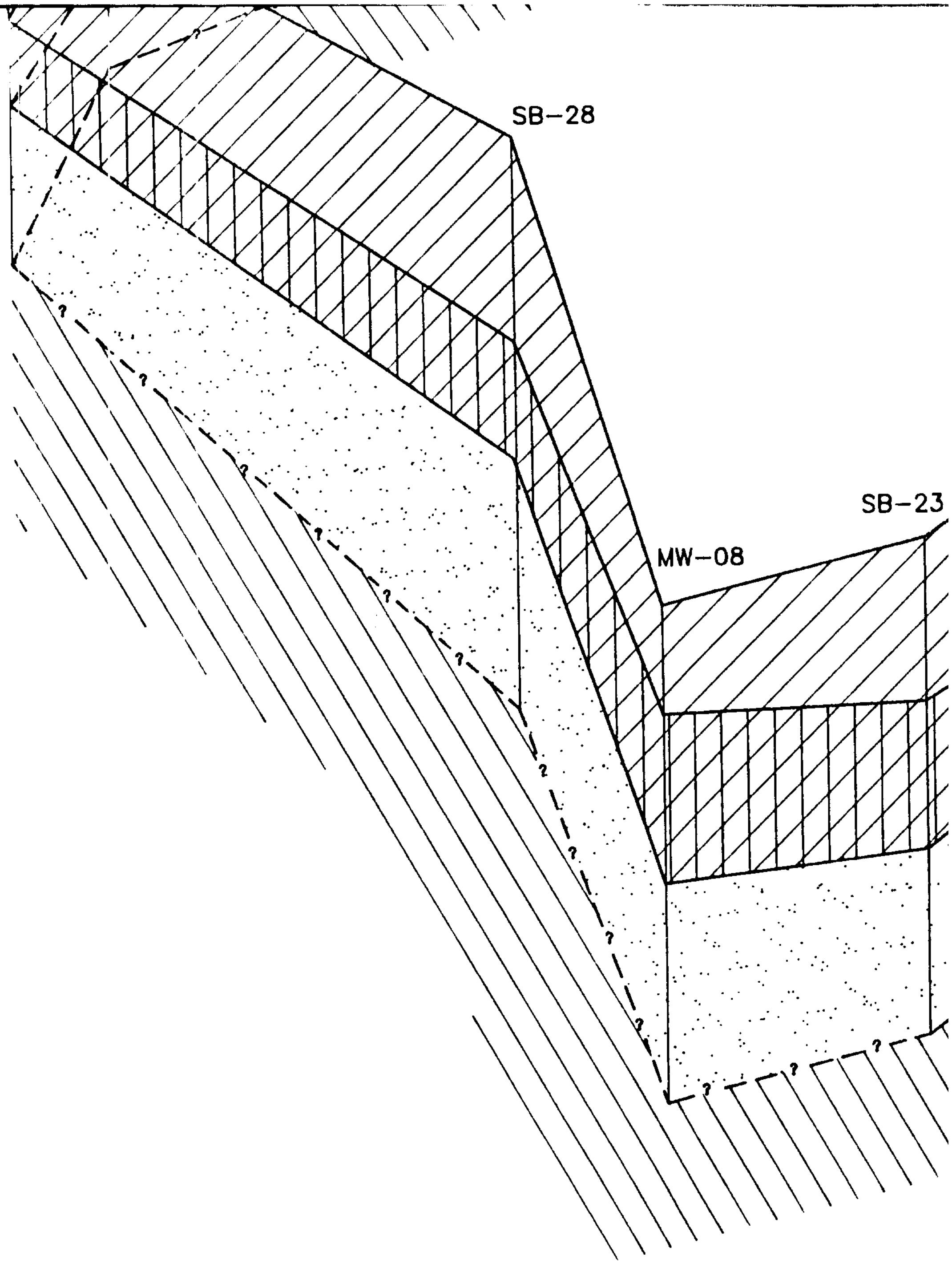


3

LEGEND

- ZONE 1A (CLAY)
- ZONE 1B (SILTY CLAY)
- ZONE 2 (CLAYEY SILT AND SILTY SAND)
- ZONE 3 (SILTY CLAY)

IW-13

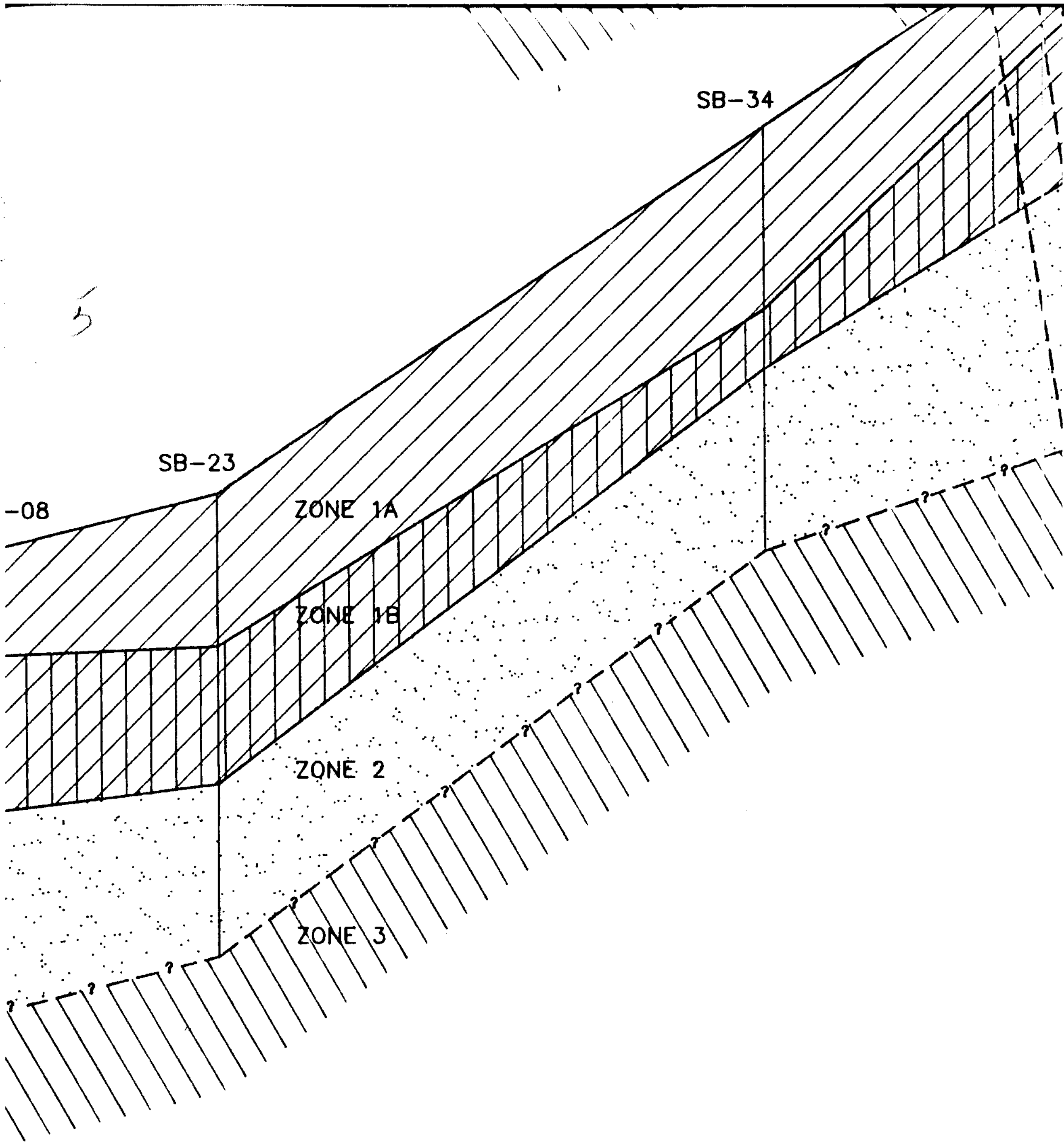


4

VERTICAL SCALE : 1" = 10'

HORIZONTAL SCALE : 1" = 40'

5



DRAWN BY	D. GROSSHANDLER
DATE:	10/26/93
GEOLOGIST:	L. BASILO
DATE:	10/26/93
CAD DWG. NO.	L-2.DWG

ELLI

SCALE: A

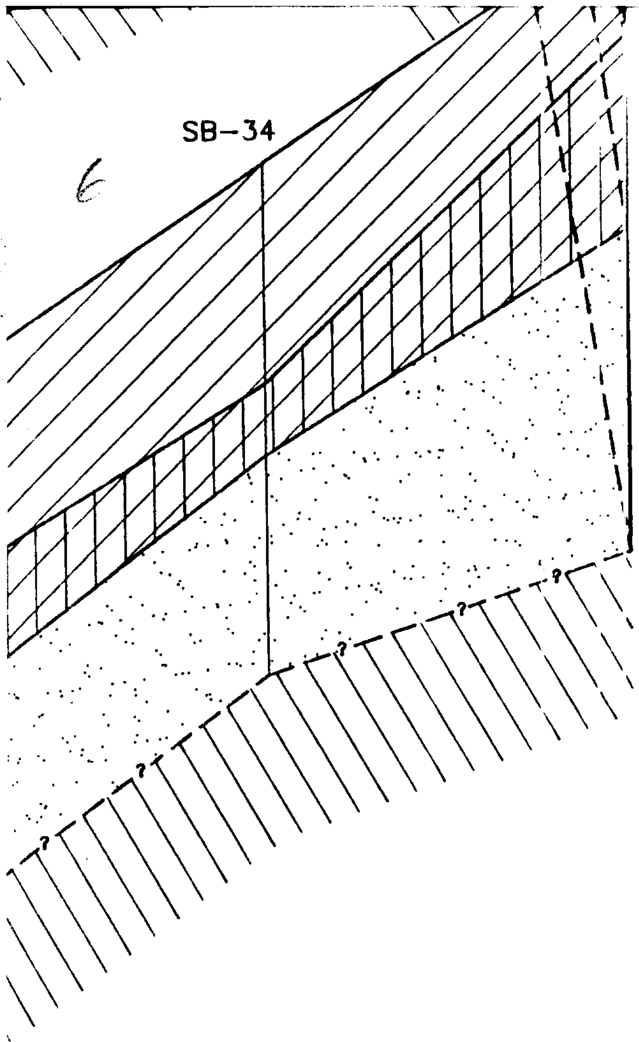


FIGURE 4-5

DRAWN BY	D. GROSSHANDLER	FENCE DIAGRAM POL STORAGE AREA ELLINGTON FIELD (ANG) HOUSTON, TEXAS		
DATE:	10/26/93			
GEOLOGIST:	L. BASILO			
DATE:	10/26/93			
CAD DWG. NO.	L-2.DWG	SCALE: AS NOTED	BRE. DWG. NO.: 1K94-DA	REV. 0

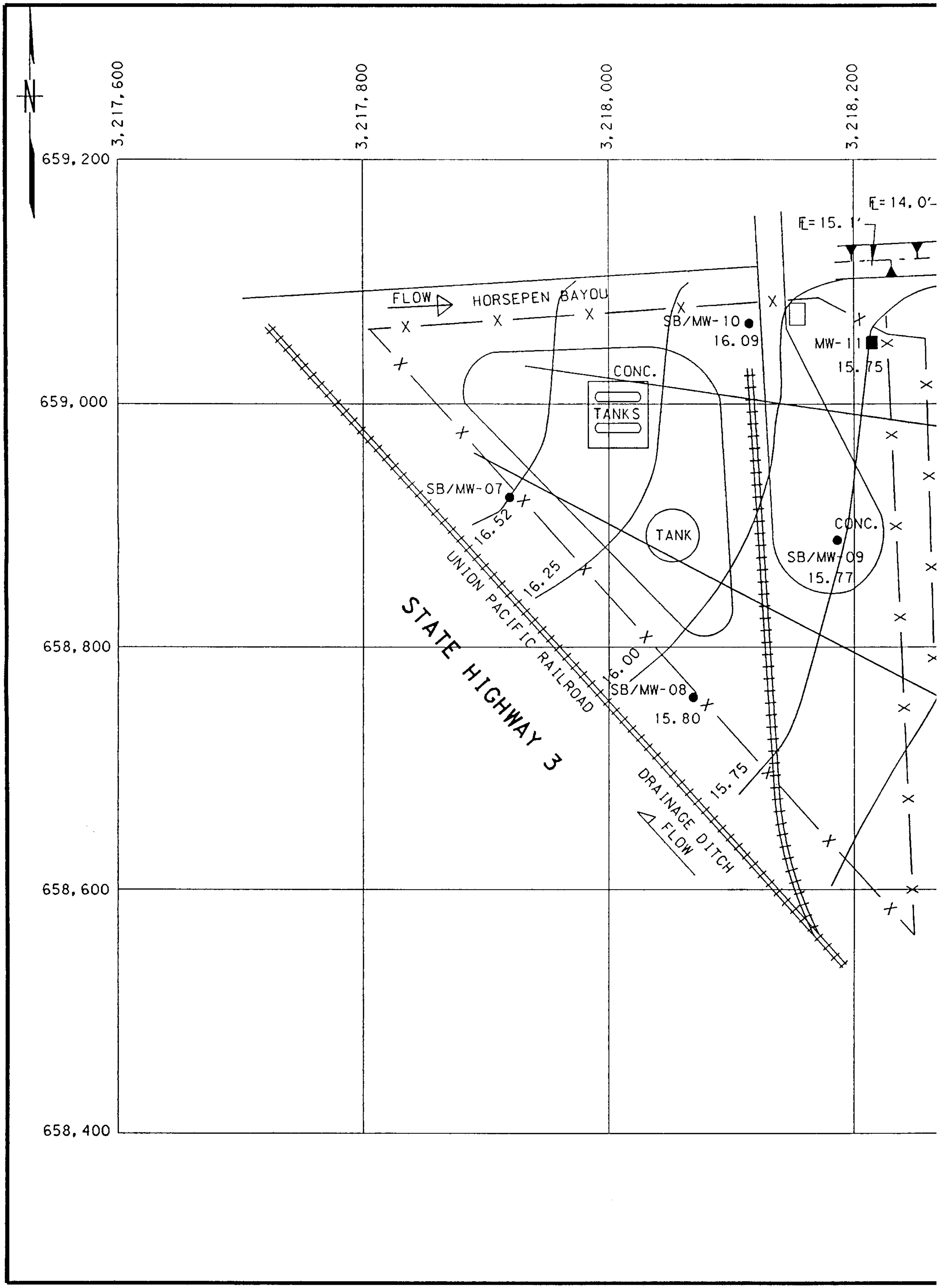
Br

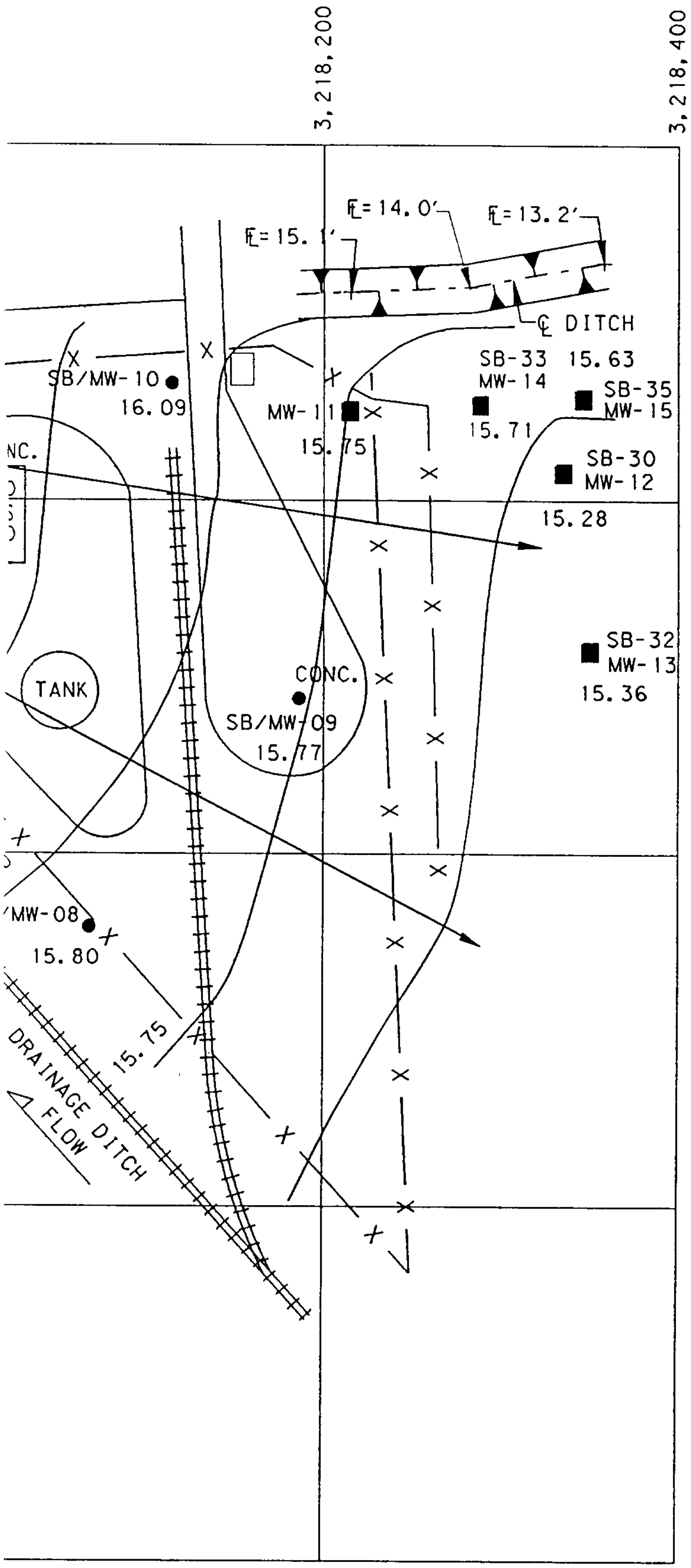
PA

7

FIGURE 4-5

DLER	FENCE DIAGRAM POL STORAGE AREA ELLINGTON FIELD (ANG) HOUSTON, TEXAS	Brown & Root Environmental A Halliburton Company
	SCALE: AS NOTED | BRE. DWG. NO.: 1K94-DA | REV. 0	


N
3,217,600
3,217,800
3,218,000
3,218,200
659,200
659,000
658,800
658,600
658,400
℄=14.0'
℄=15.1'
FLOW
HORSEPEN BAYOU
SB/MW-10
16.09
MW-11
15.75
CONC.
TANKS
SB/MW-07
16.52
TANK
CONC.
SB/MW-09
15.77
16.25
STATE HIGHWAY 3
UNION PACIFIC RAILROAD
16.00
SB/MW-08
15.80
15.75
DRAINAGE DITCH
FLOW



LEGEND:

■ MW = MONITOR WELL
● SB = SOIL BORING
NG = NATURAL GROUND
CONC. = CONCRETE

GROUNI

DRAINA

HORSEI

NOTES:

1. ALL ELEVATIONS SHOWN HEREON ARE BASED ON I M-1276 WITH ELEVATION OF 24.52 FEET, NGVD 1987 ADJUSTMENT.
2. ALL COORDINATES ARE REFERENCED TO THE TEX SOUTH CENTRAL ZONE AND ARE BASED ON U.S.C. MARKER ELLINGTON 1952 HAVING COORDINATES EAST: 3,215,019.21 WITH A GRID FACTOR OF
3. MONITOR WELLS MW-07 THROUGH MW-10 AND SOI THROUGH SB-14 WERE INSTALLED IN JANUARY 1

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SURVEYED BY:	JDC
DRAWN BY:	D. GROSSH
CHECKED BY:	L. BAS

 HOU07US -

LEGEND:

MW = MONITOR WELL
SB = SOIL BORING
NG = NATURAL GROUND
CONC. = CONCRETE

GROUNDWATER FLOW DIRECTION
DRAINAGE DITCH FLOW DIRECTION
HORSEPEN BAYOU FLOW DIRECTION

NOTES:

1. ALL ELEVATIONS SHOWN HEREON ARE BASED ON NGS BENCHMARK M-1276 WITH ELEVATION OF 24.52 FEET, NGVD 1929 DATUM, 1987 ADJUSTMENT.
2. ALL COORDINATES ARE REFERENCED TO THE TEXAS COORDINATE SYSTEM, SOUTH CENTRAL ZONE AND ARE BASED ON U.S.C. & G.S. SURVEY MARKER ELLINGTON 1952 HAVING COORDINATES OF NORTH: 662,268.83, EAST: 3,215,019.21 WITH A GRID FACTOR OF 0.9998723.
3. MONITOR WELLS MW-07 THROUGH MW-10 AND SOIL BORINGS SB-11 THROUGH SB-14 WERE INSTALLED IN JANUARY 1990 DURING THE SI.

FIGURE 4-6

HALLIBURTON NUS
Environmental Corporation

GROUNDWATER ELEVATION
CONTOUR MAP
AUGUST 27, 1993
POL STORAGE AREA
ELLINGTON FIELD (ANG.)
HOUSTON, TEXAS

SURVEYED BY:	JDC	SCALE:	1" = 100'
DRAWN BY:	D. GROSSHANDLER	DATE:	09-10-93
CHECKED BY:	L. BASILIO	JOB NO.:	NQ-1K94-BB

HOU07US - /USR19A/HCIVIL/910333/NQ1K94BB.DGN-02

Zone 2 is the first zone with sufficient permeability to allow observable groundwater to readily enter the borehole. Shallow groundwater at the site appears to occur under semi-confined conditions. The semi-confined aquifer conditions occur where sharp contrasts in vertical permeability exist (e.g., at the boundary between Zones 1B and Zone 2, where the coarser grained silt/sand aquifer is overlain by a tight clay). The observed static water level was several feet above the top of the shallow aquifer in all cases pertaining to monitoring wells which were installed at the locations discussed above. The potentiometric surface was encountered at depths ranging from approximately 6.7 feet below land surface (BLS) in monitoring well MW-7 to approximately 10.1 feet BLS in monitoring well MW-11.

Groundwater elevations recorded for Monitoring Wells MW-07 through MW-10 during the SC are higher than those recorded during the SI in January, 1990. Such a difference is noteworthy because the summer of 1993 in the Houston area was distinguished by its lack of rainfall, with little measurable precipitation in the two months preceding the SC. The observed difference in groundwater elevations may be attributable to the fact that Horsepen Bayou was concreted over and this disrupted the interaction between groundwater and surface water (i.e., reduced groundwater discharge into Horsepen Bayou).

Groundwater flow direction in 1990 and 1993 is essentially unchanged except for minor deviations at the extremes of the recording area. The hydraulic gradient is shallower in 1993 (14 feet/mile) than in 1990 (79 feet/mile).

4.1.2.1 Aquifer Parameter Estimates

Slug tests were performed on all five monitoring wells installed during the SC to estimate hydraulic conductivities and transmissivities for Zone 2. Falling head (slug in) and rising head (slug out) tests were performed at each monitoring well. The equalization of head was recorded with a Model SE 1000C Hermit Environmental Data Logger.

Hydraulic conductivities were calculated using the slug test method of Bouwer and Rice, 1976. Graphical solutions and calculations were performed using AQTESOLV, an aquifer test analysis software package. Aquifer test data and

calculations are included in Appendix F. Several assumptions were made in the evaluation of slug test data. These assumptions are as follows:

- The aquifer is homogenous and isotropic
- Head losses as water enters the well are negligible
- Flow above the water table is typically ignored because it does not significantly affect slug test data
- The change in head is instantaneous
- Soils above and below Zone 2 contribute negligibly to equalization of head in the well during the test
- Time and "head" translational data, rather than theoretical estimates of head changes with time, were utilized when performing the slug test calculations to avoid instrument noise at the beginning of the test (i.e., the first consistent time/head values were used at H(0); Pandit et al, 1986).

Table 4-1 presents hydraulic conductivity estimates for rising and falling head tests at each monitoring well location. Hydraulic conductivities ranged from 2.69 x 10^{-4} cm/sec (0.763 ft/day) to 9.32 x 10^{-4} cm/sec (2.644 ft/day). The hydraulic conductivities for Zone 2 are within the published range of values for silts and silty sands (Freeze & Cherry, 1979).

In addition to hydraulic conductivity, transmissivities of the sediments surrounding each monitoring well were determined based upon the thickness of the permeable aquifer materials. These estimates are also presented in Table 4-1. Estimated transmissivities ranged from 77.04 gpd/ft (10.30 ft^2/day) to 266.96 gpd/ft (35.69 ft^2/day). A saturated aquifer thickness of 13.5 feet was used in calculating the transmissivities. This number is based on an average aquifer thickness as calculated from borings drilled during the SI. SI soil borings SB-08, -09, and -10 fully penetrated Zone 2. None of the borings drilled during the SC fully penetrated the aquifer. Hydraulic conductivities and transmissivity are greatest in monitoring wells MW-12 and MW-13, which are located to the east of the POL Storage Area on City of Houston property.

4.1.2.2 Rate of Groundwater Movement

A variation of Darcy's Law is used to estimate seepage velocity of groundwater in a porous media. The seepage velocity represents the rate at which water actually

TABLE 4-1

ESTIMATES OF IN-SITU HYDRAULIC CONDUCTIVITY AND TRANSMISSIVITY
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Well No.	Thickness of Unit (feet)[(1)]	Hydraulic Conductivity				Transmissivity			
		Falling Head		Rising Head		Falling Head		Rising Head	
		CM/SEC	FT/DAY	CM/SEC	FT/DAY	FT^2/DAY	GAL/DAY/FT	FT^2/DAY	GAL/DAY/FT
MW-11	13.5	2.84×10^{-4}	0.81	2.69×10^{-4}	0.76	10.88	81.38	10.30	77.04
MW-12	13.5	8.38×10^{-4}	2.38	9.32×10^{-4}	2.64	32.08	239.96	35.69	266.96
MW-13	13.5	8.43×10^{-4}	2.39	8.74×10^{-4}	2.48	32.26	241.30	33.44	250.13
MW-14	13.5	2.92×10^{-4}	0.83	2.73×10^{-4}	0.78	11.21	83.85	10.47	78.32
MW-15	13.5	2.96×10^{-4}	0.84	2.95×10^{-4}	0.84	11.34	84.82	11.30	84.52

(1) Average aquifer thickness based on SI data.

moves through the pore spaces. It should be noted that the movement of chemical compounds in groundwater is difficult to determine as a result of dilution, dispersion, adsorption, and degradation within the natural environment. Thus the migration of chemical compounds may not correlate with groundwater flow estimates.

Darcy's Law is defined as:

$$V = K\, i/n$$

where:

V = Darcian seepage velocity
K = hydraulic conductivity
i = hydraulic gradient
n = effective porosity

Using this equation, estimates of groundwater flow velocities have been calculated for a range of effective porosities applicable to the sediments at the site. Table 4-2 presents Darcian seepage velocity estimates. The estimates range from a minimum of 3.01 feet/year to a maximum of 52.2 feet/year. Seasonal fluctuations in the potentiometric surface could affect the net annual seepage velocity. Changes in the water elevation could affect the direction of groundwater flow or the hydraulic gradient.

4.2 Contaminant Occurrence And Distribution

This section summarizes information on the nature and extent of contamination at the site by presenting laboratory analytical results for soil and groundwater samples collected by Halliburton NUS during the SC. Tables 4-3 and 4-4 summarize the number and type of analyses performed. Tables 3-1 and 3-2 depict the analyses performed on each individual sample. The laboratory analytical reports for samples pertinent to the SC are contained in Appendix G. The analytical data presented in these tables were subjected to a data validation process in order to ensure the integrity and defensibility of the data. Data validation reports are located in Appendix H. Soil and groundwater samples collected during this SC were analyzed by PACE Laboratories of Houston, Texas.

TABLE 4-2

ESTIMATES OF DARCIAN SEEPAGE VELOCITY
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Hydraulic Gradient (ft/ft)	Effective Porosity[a]		Hydraulic Conductivity[b] (ft/day)		Darcian Seepage Velocity (ft/day)		Darcian Seepage Velocity (ft/year)	
	Low	High	Low	High	High	Low	High	Low
0.0027	0.05	0.25	0.763	-	4.12×10^{-2}	8.24×10^{-3}	15.0	3.01
0.0027	0.05	0.25	-	2.64	0.143	0.029	52.2	10.6

(a) Effective porosity estimates based on estimates of specific yield for similar soil types from Fetter, 1979 Applied Hydrogeoloy

(b) Hydraulic conductivities based on range presented in Table 4-1.

TABLE 4-3

SUMMARY OF LABORATORY ANALYSIS OF SOIL SAMPLES
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Parameter	Analytical Method	QC Level	Number Environmental Samples	Number Field Duplicates	Number Trip Blanks	Number of Field/Risate Blanks	Total Number Environmental and QA/QC	Laboratory Duplicates MS/MSD (a)	Total Lab QA/QC	Grand Total
TCL Volatiles [b]	CLP[c]	C	5	1	5	2/4	16	1/1	2	18
TCL BNA	CLP	C	5	-	--	2/4	11	1/1	2	13
Total Petroleum Hydrocarbons	EPA 418.1	C	65	7	--	2/7	81	5/5	10	91
BTEX	EPA 8020	C	57	6		0/3	72	4/4	8	80

(a) MS/MSD - Matrix Spike/Matrix Spike Duplicate
(b) TCL - Target Compound List
(c) CLP - Contract Laboratory Program, March 1990 for organic parameters

TABLE 4-4

SUMMARY OF LABORATORY ANALYSIS OF GROUNDWATER SAMPLES
POL STORAGE AREA
ELLINGTON FIELD AIR NATIONAL GUARD BASE

Parameter	Analytical Method	QC Level	Number Environmental Samples	Number Field Duplicates	Number Trip Blanks	Number of Field/Risate Blanks	Total Number Environmental and QA/QC	Laboratory Duplicates MS/MSD (a)	Total Lab QA/QC	Grand Total
TCL Volatiles [b]	CLP[c]	C	3	1	1	0/1	6	1/1	2	8
TCL BNA	CLP	C	3	1	--	0/1	5	1/1	2	7
Total Petroleum Hydrocarbons	EPA 418.1	C	9	1	--	0/1	11	2/2	4	15
BTEX	EPA 8020	C	6	-	--	-	6	1/1	2	8
Total Dissolved Solids	160.1	C	3	-	-	-	3	-	-	3

(a) MS/MSD - Matrix Spike/Matrix Spike Duplicate
(b) TCL - Target Compound List
(c) CLP - Contract Laboratory Program, March 1990 for organic parameters

4.2.1 Regulatory Guidance

The analytical results for soil and groundwater samples collected during this investigation are compared to action levels as stated in Guidance Manual For LPST Cleanups In Texas, January 1990, TNRCC.

For soils, the action limit is 100 mg/kg TPH and 30 mg/kg total BTEX.

Figure 4-7 is a flowchart depicting the groundwater cleanup goals applicable to the site.

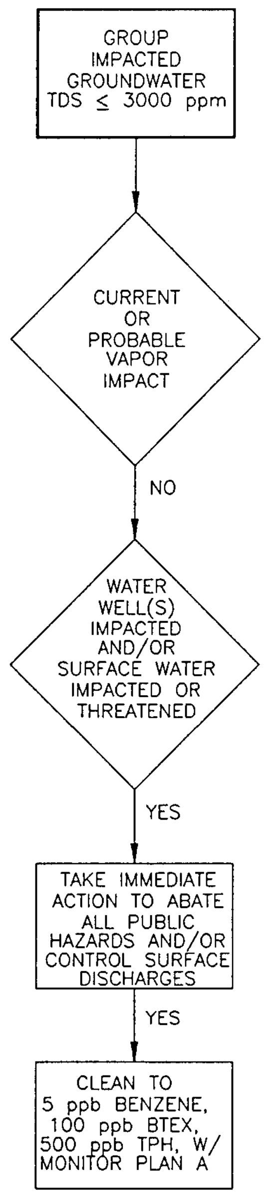
For constituents not listed in the above referenced guidance document, Media Specific Concentrations (MSC) (Appendix II, TNRCC Risk Reduction Rules, June 15 1993) are used for regulatory comparison. The Risk Reduction Rules adopt a risk based approach for determining the extent and type of closures or remediations which are necessary to protect human health and the environment. The requirements of the Risk Reduction Rule do not apply to underground storage tank (UST) sites. The MSCs are used strictly for comparative purposes for a constituent not covered by the UST regulations. The residential standards of the Risk Reduction Rules are the most stringent and therefore are the ones employed. These standards may not represent actual conditions at the site and are used for comparison only.

4.2.2 Subsurface Soil Samples

A total of 72 subsurface soil samples (65 samples plus 7 duplicates) from 22 soil borings were collected for environmental analysis. All soil samples were analyzed for TPH (Method 418.1). All but eight soil samples were analyzed for BTEX (Method 8020). Five selected soil samples were analyzed for TCL volatiles (CLP method) and TCL BNAs (CLP method). These analyses were performed to provide data for future risk assessment activities, should they be deemed appropriate. Three other soil samples, those from soil boring SB-15, were analyzed only for TPH. The request for BTEX analyses for the samples collected from SB-15 was inadvertently omitted from the chain of custody form sent to the analytical laboratory. The analytical results for detected compounds for subsurface soil samples are presented in Table 4-5. TPH concentrations ranged fron non-detect in 11 of the 22 soil borings to a maximum of 54 mg/kg in the 2-4 foot interval of soil boring SB-17.

FIGURE 4-7

GROUNDWATER REMEDIATION FLOWCHART



MONITOR PLAN A

AT LEAST 1 DOWNGRADIENT NONIMPACTED MONITOR WELL. QUARTERLY SAMPLING OF ALL MONITOR WELLS FOR BTEX AND TPH. QUARTERLY WATER LEVEL MEASUREMENTS FROM ALL MONITOR WELLS.

SOURCE : TEXAS WATER COMMISSION, GUIDANCE MANUAL FOR LPST CLEANUPS IN TEXAS, JANUARY 1990.

12/04/93
ELL-1.DWG

TABLE 4-5

CONCENTRATIONS OF ANALYTES DETECTED IN SUBSURFACE SOIL SAMPLES (1)
POL Storage Area
Ellington Field Air National Guard Base

Sample ID	Soil Boring	Sample Depth	TPH (3) (mg/kg)	Benzene (4) (ug/kg)	Toluene (4) (ug/kg)	Ethylbenzene (4) (ug/kg)	Xylene (4) (ug/kg)	Total BTEX (4) (ug/kg)
Detection Limit			21-29(2)	5	5	5	5	
02-SB15-A-A	SB-15	0-2	35					
02-SB15-C-A	SB-15	20-22	49					
02-SB16-A-A	SB-16	4-6	40		33J	32J	21J	94
02-SB16-B-A	SB-16	8-10	41					
02-SB16-C-A	SB-16	20-22	37					
02-SB17-A-A	SB-17	2-4	54					
02-SB17-B-A	SB-17	8-10	42					
02-SB17-C-A	SB-17	22-24	38					
02-SB18-A-A	SB-18	0-2	50					
02-SB18-B-A	SB-18	10-12	38					
02-SB18-C-A	SB-18	18-20	37					
02-SB20-A-A	SB-20	2-4	39			7.9J		22.9
02-SB20-C-A	SB-20	20-22	36					
02-SB21-A-A	SB-21	2-4				8.8J		23.8
02-SB21-B-A	SB-21	4-6	49					
02-SB21-C-A	SB-21	20-22	49					
02-SB22-C-A	SB-22	22-24	38					
02-SB23-B-A	SB-23	6-8				16J		31
02-SB25-B-A	SB-25	5-7			90J	700J	67J	862
02-SB26-A-A	SB-26	0-2	43					
02-SB26-B-A	SB-26	6-8			2J	170	43	228
02-SB26-C-A	SB-26	18-20		180J	190J	960J	57J	1387
02-FD26-C-A	SB-26	18-20				11J	<5J	26
02-SB27-B-A	SB-27	14-16		3000	8000	2500	9900	23400
02-SB28-A-A	SB-28	1-3			7.3J			22.3
02-SB28-B-A	SB-28	7-9			7.6J			22.6
02-SB29-A-A	SB-29	1-3		12J		25J		47
02-SB31-B-A	SB-31	10-12		24J	85J	250J	150J	509
02-SB34-A-A	SB-34	0-2	38J					
02-SB35-B-A	SB-35	16-18	25J					
02-MW11-A-A	MW-11	0-2	24					

J Lab qualifier indicating estimated value. If field is left blank, the qualifier is A - Accept all data
(1) No entry indicates parameter not detected above quantitation limit
(2) Detection limit varied
(3) Analyzed by EPA Method 418.1
(4) Analyzed by CLP SOW OLM01.0 Method

All samples analyzed contained TPH concentrations below the 100 mg/kg TPH concentration limit set by the TNRCC.

Benzene concentrations ranged from non-detect in seventeen of the twenty two soil borings to a maximum of 3000 ug/kg in the 14-16 foot interval of soil boring SB-27.

Toluene concentrations ranged from non-detect in fifteen of the twenty two soil borings to a maximum of 8000 ug/kg in the 14-16 foot interval of soil boring SB-27.

Ethylbenzene concentrations ranged from non-detect in twelve of the twenty two soil borings to a maximum of 2500 ug/kg in the 14-16 foot interval of soil boring SB-27.

Xylene concentrations ranged from non-detect in sixteen of the twenty two soil borings to a maximum of 9900 ug/kg in the 14-16 foot interval of soil boring SB-27.

In all the soil samples analyzed, total BTEX concentrations were below the 30000 ug/kg (30 mg/kg) action level set by the TNRCC.

Five of the soil samples collected were analyzed for TCL volatile compounds. In four of the samples (02SB16BA, 02SB18BA, 02SB19AA, and 02SB20BA), TCL volatile concentrations were reported below laboratory detection levels. 2-butanone was detected in one sample (02SB26BA). This compound is considered a laboratory artifact and is not considered indicative of the environment at the POL Storage Area.

These five samples were also analyzed for TCL BNAs. In all five samples, semi-volatile concentrations were below laboratory detection levels.

4.2.3 Groundwater Samples

A groundwater sample was collected from each of the nine monitoring wells at the site. Groundwater samples were analyzed for TPH (Method 418.1) and BTEX

(Method 8020). Additionally, groundwater samples from Monitoring Wells MW-07, 10, and 11, were analyzed for TCL volatiles (CLP method), TCL BNAs CLP method) and a total dissolved solids (TDS) (Method 160.1). Groundwater monitoring wells were purged until field parameters reached equilibrium or a minimum of three well volumes were removed. The pH, temperature, conductivity, and turbidity of the groundwater samples were measured at the time of sampling and were recorded on the groundwater sample log sheets located in Appendix C. The analytical results for detected compounds for these samples are presented in Table 4-6.

Total dissolved solids concentrations were reported between 600 and 680 mg/l. This places the first aquifer below the site in Group I of the State of Texas groundwater classification system. The State of Texas has developed a groundwater quality classification based on TDS. Group I is groundwater with TDS concentration less than 3000 mg/l. Group III is groundwater with TDS concentration between 3000 mg/l and 10000 mg/l. Group II is groundwater with TDS concentration greater than 10000 mg/l. Groundwater cleanup levels for UST sites are determined in part by the TDS of the affected groundwater.

TPH concentrations in groundwater ranged from non-detect in five of the nine monitoring wells to a maximum of 0.4 mg/l in monitoring well MW-08.

TPH concentrations in groundwater samples collected are below the 0.5 mg/l clean-up level established by the TNRCC.

Benzene, toluene, ethylbenzene and xylene were reported as non-detect in all monitoring wells sampled.

BTEX concentrations in groundwater samples collected are less than the 100 ug/l total BTEX limit set by the TNRCC.

Acetone and carbon disulfide were reported at concentrations of 5 ug/l and 38 ug/l, respectively, in the sample from monitoring well MW-11. Acetone is a common lab contaminant and is not considered indicative of the environment at the site. The concentration of carbon disulfide is below TNRCC Risk Reduction standard of 3650 ug/l. All other TCL volatile compounds were reported as non-detect.

TABLE 4-6

CONCENTRATIONS OF ANALYTES DETECTED IN GROUNDWATER SAMPLES[1]
POL Storage Area
Ellington Field Air National Guard Base

Parameter	Sample ID	Cleanup Level	Detection Limit	02MW07AA	02MW08AA	02MW10AA	02FD10AA	02MW11AA	02MW14AA
	Source			MW-07	MW-08	MW-10	MW-10	MW-11	MW-14
Total Petroleum Hydrocarbons[3]	mg/l	0.5	0.2	0.2J	0.4J			0.2J	0.2J
Acetone[4]	ug/l	NA	10					5J	
Carbon disulfide[4]	ug/l	NA	10					38	
Bis(2-Ethylhexyl)phthalate[4]	ug/l	NA	10			3J	2J	4J	

J Lab qualifier indicating estimated value
(1) No entry indicates parameter not detected above quantitation limit
(2) TNRCC, Guidance Manual for LPST Cleanups in Texas, January 1990
(3) Analyzed by EPA Method 418.1
(4) Analyzed by CLP SOW OLM01.0 Method
NA No MCL for this compound

TCL semi-volatiles were reported as non-detect in all samples except for bis(2-ehylhexyl)phthalate at concentrations of 3 ug/l and 4 ug/l in monitoring wells MW-10 and MW-11, respectively. Bis(2-ethylhexyl)phthalate is considered a sampling artifact and is not considered indicative of the environment at the POL Storage Area. The detected concentrations are below TNRCC Risk Reduction standard of 6.08 ug/l for bis (2-ethylhexyl) phthalate.

4.2.4 Field Quality Control Samples

Field Quality Assurance/Quality Control (QA/QC) samples were collected during the course of the field sampling program in order to provide data quality assurance. Quality control samples included trip blanks, equipment (rinsate) blanks, field blanks, and field duplicates. The type and number of field QC samples are listed in Tables 4-3 and 4-4. Each type of field quality control sample collected is defined as follows:

Equipment (Rinsate) Blanks - Equipment blanks are obtained under representative field conditions by pouring reagent-grade water through decontaminated sample collection equipment (bailer, split-spoon, etc.) and placing the water in appropriate sample containers for analysis. Equipment blanks are used to test the effectiveness of decontamination procedures.

Field Duplicates - Field duplicates are two samples collected independently at a sampling location during a single act of sampling under representative field conditions. Both duplicates are analyzed for the same laboratory parameters. As soil samples were collected in brass tube samplers, two tubes from the same split spoon were submitted.

Trip Blanks - Trip blanks are prepared and provided by the analytical laboratory. Trip blanks are subjected to the same conditions as field samples.

Field Blanks - Field blanks are samples of source water used for decontamination. Field blanks are analyzed to ensure that the water used for decontamination is free of analytes which may interfere with the required laboratory analyses.. Field blanks were collected from the reagent grade water and potable water used during field operations.

Table 4-7 depicts the analytical results for detected compounds for these samples.

TABLE 4-7

CONCENTRATION OF ANALYTES DETECTED IN FIELD QA/QC BLANKS(1)
POL Storage Area
Ellington Field Air National Guard Base

Parameter	Sample ID	02RB01AA	02RB02AA	02RB03AA	02RB05AA	02RB08AA	02FB01AA
Methylene chloride	ug/kg	6	6	4	6	2	7
Ethylbenzene	ug/kg				2J		
1,2,4-Trichlorobenzene	ug/kg	29					
Pyrene	ug/kg	81					

J = lab qualifier indicating estimated value
(1) No entry indicates parameter not detected above Quantitation limit

No volatile organic compounds were detected in any of the trip blanks submitted.

Methylene chloride was detected in very low concentrations (<6 ug/kg) in five of the equipment rinsate blanks. Acetone was detected in one of the equipment rinsate blanks at a concentration of 31 ug/l. These compounds are considered laboratory artifacts. Ethylbenzene was detected in one of the rinsate blanks at a concentration of 2 ug/l. Two semi-volatiles, 1,2,4-trichlorobenzene and pyrene, were detected in one of the equipment rinsate blanks at concentrations of 29 ug/kg and 81 ug/kg, respectively.

It is believed that the pyrene and 1,2,4-trichlorobenzene in rinsate blank RB01AA are lab contaminants These two compounds are matrix spike compounds and there may have been some cross contamination in the laboratory. Both levels of these compounds are below the reporting limits. HAZWRAP protocols, however, require that detections in blank samples not be given a qualifier. There were no detections of either compound in any of the soil or groundwater samples.

Ethylbenzene in rinsate blank RB05AA may indicate that decontamination procedures used that day may not have been as thorough as other days. The level of ethylbenzene in the blank sample is, however, below the reporting limit. Also none of the samples associated with this rinsate blank were qualified as a result of ethylbenzene in the rinsate blank

Methylene chloride was detected at a concentration of 7 ug/l in one of the field blanks. This compound is also considered to be a laboratory artifact.

4.2.5 Data Validation Procedures

Data validation was performed on all of the laboratory analytical data used to support the SC. Data validation is an independent, systematic review of laboratory analytical results to confirm that the data are of the technical quality to meet their intended use. The data for these analyses were reviewed with reference to the EPA "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" and HAZWRAP "Requirements for Quality Control of Analytical Data". The analyses were conducted under HAZWRAP Level C QA/QC criteria and were evaluated according to the following parameters:

- Holding times
- Laboratory blank analyses
- Surrogate spike recoveries

- Matrix spike/matrix spike duplicate results
- Laboratory control sample results
- Internal standards
- Detection limits
- Laboratory performance
- Tentatively identified compounds
- Data completeness
- GC/MS tuning and mass calibration
- Initial and continuing calibrations
- Field duplicate precision

Data qualifiers were assigned to the analytical data to alert the user to any limitations based on QA/QC requirements. Appendix H presents the data validation records.

4.2.6 Quality Assurance/Quality Control Summary

This section contains a general summary of the results of quality control measures used to assess and control the fixed-base laboratory analytical process. Data reports of the analyses performed for this project were reviewed in accordance with EPA document "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" and HAZWRAP "Requirements for Quality Control of Analytical data." Laboratory analyses were conducted under HAZWRAP Level C QA/QC criteria. Data packages were in general evaluated for:

- Data completeness
- Holding times
- Initial and continuing calibrations
- Laboratory blank analyses
- Surrogate spike recoveries
- Matrix spike/matrix spike duplicate results
- Field duplicate precision
- Detection limits

Data validation reports found in Appendix H of this report describe any irregularities with reported analytical data. A brief explanation of data qualifiers is provided below. Appendix H contains detailed summaries of method blanks results, matrix spike/matrix spike duplicate results, surrogate recoveries, field duplicate results, and field blank results.

Soil Samples

PACE Laboratories analyzed 72 soil samples (65 samples plus 7 duplicates) for TPH and BTEX. In addition, five samples were analyzed for TCL volatiles and semivolatiles. Field quality control blanks included 7 rinsate blanks and 11 trip blanks. All holding times associated with this data set met HAZWRAP requirements. All data points associated with this sample set were accepted, although several analytes were accepted with qualifiers. Table 4-8 lists the sample, the qualifier assigned to that sample, the parameter affected and the reason a qualifier was assigned.

Groundwater Samples

PACE Laboratories analyzed nine groundwater plus one duplicate for TPH and BTEX. In addition, three samples were analyzed for TCL volatiles and semivolatiles. Field quality control blanks included 1 rinsate blank and 1 trip blank. All holding times associated with this data set met HAZWRAP requirements. All data points associated with this sample set were accepted, although several analytes were accepted with qualifiers. Table 4-9 lists the sample, the qualifier assigned to that sample, the parameter affected and the reason a qualifier was assigned.

Table 4-8

Quality Control Summary
Soil Samples

SAMPLE I.D.	QUALIFIER	PARAMETER	REASON
02SB16AA	J	Benzene Toluene Ethylbenzene Xylene	Estimate positive results and non detects as a result of high surrogate Percent Recovery
02SB18BA	J	Acetone	Estimate non detected results for acetone as a result of initial and continuing calibrations Percent Relative Standard Deviation and Percent Differences greater than 50%.
02SB19AA	J	Acetone	Estimate non detected results for acetone as a result of initial and continuing calibrations Percent Relative Standard Deviation and Percent Differences greater than 50%.
02SB20AA	J	Ethylbenzene	Estimate positive results as a result of high surrogate Percent Recoveries
02SB20BA	J	Acetone	Estimate non detected results for acetone as a result of initial and continuing calibrations Percent Relative Standard Deviation and Percent Differences greater than 50%.

02SB20BA	J	Phenol 2-chlorophenol 1,4-Dichlorobenzene N-Nitro-Di-n-Propylamine 1,2,4-Trichlorobenzene 4-chloro-3-methylphenol Acenaphthene 4-Nitrophenol 2,4-Dinitrotoluene Pentachlorophenol Pyrene	Estimate non detected results as a result of noncompliant surrogate Percent Recovery and Relative Percent Difference in the semivolatile MS/MSD analyses.
02SB21AA	J	Ethylbenzene	Estimate positive result as a result of high surrogate Percent Recovery
02SB21AA	J	Toluene	Estimate non detect as a result of low matrix spike Percent Recovery and high Relative Percent Difference
02SB23BA	J	Ethylbenzene	Estimate positive results as a result of high surrogate Percent Recovery
02SB25BA	J	Toluene Ethylbenzene Xylene	Estimate positive results as a result of high surrogate Percent Recovery
02SB26BA	J	2-butanone	Estimate positive results as a result of continuing calibration Percent Difference greater than 50%
02SB26BA	J	Toluene	Estimate positive result reported at concentrations below CRQL
02SB26CA	J	Benzene Toluene Ethylbenzene Xylene	Estimate positive results as a result of high surrogate Percent Recovery
02FD26CA	J	Benzene Toluene Ethylbenzene Xylene	Estimate non detected results as a result of poor field duplicate precision

02FD26CA	J	Ethylbenzene	Estimate positive results as a result of high surrogate Percent Recovery
02SB28AA	J	Toluene	Estimate positive results as a result of high surrogate Percent Recovery
02SB28BA	J	Toluene	Estimate positive results as a result of high surrogate Percent Recovery
02SB29AA	J	Benzene Ethylbenzene	Estimate positive results as a result of high surrogate Percent Recovery
02SB31BA	J	Benzene Toluene Ethylbenzene Xylene	Estimate positive results as a result of high surrogate Percent Recovery
02SB34AA 02SB34BA 02SB34CA 02FD34CA	J	TPH	Estimate positive results and non detect as a result of low matric spike recovery

Table 4-9

Quality Control Summary
Groundwater Samples

SAMPLE I.D.	QUALIFIER	PARAMETER	REASON
02MW07AA	J	TPH	Estimate positive results as a result of low recovery in the Initial Calibration Verification
02MW08AA	J	TPH	Estimate positive results as a result of low matrix spike recovery
02MW09AA	J	TPH	Estimate non detect as a result of low matrix spike recovery
02MW10AA 02FD10AA	J	TPH	Estimate non detects as a result of low recovery in the Initial Calibration Value
02MW10AA 02FD10AA	J	bis(2-ethylhexyl)phthalate	Estimate positive result for compound reported at concentrations below the CRQL
02MW11AA	J	TPH	Estimate positive results as a result of low recovery in the Initial Calibration Value
02MW11AA	J	Acetone	Estimate positive result as a result of continuing calibration Percent Difference greater than 25%
02MW11AA	J	bis(2-ethylhexyl)phthalate acetone	Estimate positive result for compound reported at concentrations below the CRQL
02MW12AA	J	TPH	Estimate non detects as a result of low matrix spike recovery
02MW13AA	J	TPH	Estimate non detects as a result of low matrix spike recovery

02MW14AA	J	TPH	Estimate non detects as a result of low matrix spike recovery
02MW15AA	J	TPH	Estimate non detects as a result of low matrix spike recovery

5.0 SUMMARY AND CONCLUSIONS

5.1 Site Characterization Summary

- A total of 22 soil borings were drilled and 5 monitoring wells were installed at the site to characterize geologic and hydrogeologic conditions for the collection of environmental samples. The horizontal and vertical locations of the soil borings and monitoring wells locations were determined by means of land survey techniques.

- A total of 72 subsurface soil (65 samples plus 7 duplicates) and 9 groundwater samples were collected at the site.

- Groundwater elevations were determined to establish groundwater flow direction and hydraulic gradient across the site. Aquifer test data were used to calculate estimates of aquifer parameters.

- Samples collected were sent to a fixed-base laboratory for chemical analysis to determine whether soil or groundwater at the site had been affected. Selected samples were also analyzed onsite using a portable field gas chromatograph.

5.2 Geologic and Hydrogeologic Summary

- A soils investigation identified three distinct stratigraphic zones beneath the site.

- Zone 2, an interval of sand and silt, is the first zone of saturated sediments beneath the site with sufficient permeability to yield groundwater to the borehole during drilling.

- Groundwater potentiometric surface elevation data indicate that groundwater flow direction is to the east.

- In-situ hydraulic conductivity tests conducted within the uppermost aquifer indicate an average hydraulic conductivity of 1.48 ft/day and an average transmissivity of 148 gpd/ft.

- TDS concentrations ranged from 600 to 680 mg/l. This places the shallow aquifer in Group I of the State of Texas groundwater classification scheme.

- Groundwater flow velocities are estimated to range from 3.0 to 52 ft/yr.

5.3 Analytical Conclusions

- For soil samples, total petroleum hydrocarbon concentrations ranged from non-detect to a maximum of 54 mg/kg.
- Benzene, toluene, ethylbenzene, and xylene were detected in several of the subsurface soil samples. Concentrations ranged from non-detect to a maximum of 23.4 mg/kg total BTEX.
- No semi-volatiles were detected in any of the soil samples.
- Concentrations of TPH and BTEX detected in all soil samples were below TNRCC cleanup limits.
- For groundwater samples, TPH concentrations ranged from non-detect to a maximum of 0.4 mg/l.
- Benzene, toluene, ethylbenzene, xylene were not detected in any of the groundwater samples. Acetone, carbon disulfide, and bis(2-ethylhexyl)phthalate were detected at very low concentrations in two of the groundwater samples.

5.4 Synthesis of Multiple Investigation Results

5.4.1 September 1989 Remedial Action

Remedial efforts to remove petroleum-contaminated materials from the railroad spur in September, 1989 resulted in the removal of most but not all of the materials which exceeded the 100 mg/kg TNRCC regulatory limit for TPH. Areas in which analysis indicated TPH concentration in excess of 100 mg/kg include the soils around the underground fuel standpipe and the east and west excavation trench walls.

5.4.2 Site Investigation

Data collected during the SI indicated minimal impact to soil and groundwater. Only one soil sample, the 0 to 2 foot interval of soil boring SB-13 at a concentration of 132 mg/kg, exceeded the TNRCC cleanup limit for TPH (i.e., 100 mg/kg TPH). Soil BTEX concentrations, where detected, were below TNRCC cleanup limits. Monitoring well MW-10 was the only monitoring well in which organic constituents were detected. However all volatile organics detected were below maximum contaminant levels. No semi-volatile constituents were detected in any of the groundwater samples.

5.4.3 Site Characterization

Data collected during the SC indicate minimal impact to the soil and groundwater. None of the fixed-base laboratory results for TPH or total BTEX in soil were in excess of TNRCC cleanup limits (i.e., 100 mg/kg TPH and 30 mg/kg total BTEX). TPH, where detected in the groundwater, was below TNRCC cleanup limits (i.e., 0.5 mg/l). BTEX was not detected in any of the groundwater samples collected from the monitoring wells.

5.5 Conclusion

From soil borings installed to the east and west of the railroad spur during the SI and SC, and from results of the remedial action, it can be concluded that soil hydrocarbon impact (i.e., in excess of TNRCC clean up levels) is minimal and is limited to the immediate vicinity of the railroad spur.

6.0 RECOMMENDATIONS

- It is recommended that the risk assessment performed as part of the SI be updated with the additional information gathered during the SC.

- If the risk assessment continues to show that no significant risks to human health exist at the POL Storage Area, it is recommended that a Decision Document be prepared substantiating that no further action is necessary at this time.

7.0 REFERENCES

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